q11
.U55
No.3306

FISH & WILDLIFE SERVICE
PACIFIC OCEANIC FISHERY
INVESTIGATIONS

AUG 14 1952

THE SIPUNCULID WORMS OF CALIFORNIA AND BAJA CALIFORNIA

BY

WALTER KENRICK FISHER

No. 3306.—From the Proceedings of the United States National Museum
Vol. 102, pp. 371–450, fig. 87, pls. 18–39

SMITHSONIAN INSTITUTION
UNITED STATES NATIONAL MUSEUM
WASHINGTON, D. C.
1952

PROCEEDINGS OF THE UNITED STATES NATIONAL MUSEUM

issued by the

SMITHSONIAN INSTITUTION
U. S. NATIONAL MUSEUM

Vol. 102 Washington: 1952 No. 3306

THE SIPUNCULID WORMS OF CALIFORNIA AND BAJA CALIFORNIA

By Walter Kenrick Fisher

Sipunculid is the name informally bestowed on members of a small phylum of marine wormlike animals of world-wide distribution—the Sipunculoidea.[1] These creatures live from the intertidal zone to oceanic depths, in tubular excavations in mud and sand, in clefts of rocks, in masses of coral, in borrowed shells, under rocks, in holdfasts of kelp, or in almost any protected situation that affords access to reasonably clear water and food. They are not found in shifting sand or mud, since in such habitats they are likely to be buried or else deprived of protection. Their food is finely divided detritus selected or trapped by the ciliated tentacles, or bottom material actively swallowed. This latter material is not necessarily finely divided. It is sometimes coarse, including the miscellaneous small fragments of the hard parts of Foraminifera, corals, bryozoans, annelids, mollusks, echinoderms, and crustaceans, often very abundant, especially in calcareous sands.

[1] Adam Sedgwick, in his "Students' Textbook of Zoology" (vol. 1, p. 594, 1898), first accorded this group phyletic rank. It had long occupied in the Annelida the position of a poor relation, as one of the orders of the class Gephyrea, in which Quatrefages also placed the Echiuroidea and Priapuloidea. "Gephyrea" either as a class or a phylum is an unnatural and unsatisfactory association, but one which has been singularly viable. It was used by Shipley (1910) in the "Cambridge Natural History" and by Borradaile and Potts (1932) in "The Invertebrata"—to mention two instances. For a good general account, consult Grace E. Pickford, "Sipunculida," Encyclopedia Brittanica, 1947; J. W. Spengel, Handworterbuch der Naturwissenschaften, vol. 9, pp. 97–106, 1913; Yves Delage and Edgard Hérouard, Traité de Zoologie Concrète, vol. 5, pp. 12–26, 1897; F. Baltzer, "Sipunculida"; Kükenthal and Krumbach's "Handbuch der Zoologie," vol. 2, pt. 9, pp. 15–61, 1931.

The region covered by this report centers in the coastal waters of California and Baja California but includes what little is known of the fauna north to the Alaskan Peninsula.

The material has been accumulating over a considerable period of years and includes specimens dredged by the United States Fisheries steamer *Albatross* in 1904. Unfortunately only about a third of the *Albatross* collection was in a condition suitable for study when it became available in 1946. The Harriman Alaska Expedition (1899), through Dr. Wesley R. Coe and the late Dr. William E. Ritter, made a small but important contribution. By far the largest collections were contributed by Prof. G. E. MacGinitie, Dr. W. F. Thompson, and the late Edward F. Ricketts. I am also indebted to the United States National Museum and the Museum of Comparative Zoology for the loan of material, to Dr. J. H. Gerould for the loan of reprints, and to Dr. Elisabeth Deichmann and Dr. Elise Wesenberg-Lund for extracts from the important works of Leuckart and Diesing.

For contributions of material thanks are due to the following persons: Dr. M. W. de Laubenfels, Dr. D. F. Hoffmeister, Dr. C. L. Hubbs, Prof. Trevor Kincaid, Dr. S. F. Light, W. H. MacGinitie, E. B. and T. T. McCabe, R. J. Menzies, Dr. E. H. Myers, Ida S. Oldroyd, D. L. Reish, Dr. N. W. Riser, Dr. Richard Synder, Dr. Emery F. Swan, Dr. H. B. Torrey, W. J. Waidzonas, Patrick H. Wells, Dr. D. L. Ray, and Dr. D. M. Wootton.

As compared with Japan the sipunculid fauna of the west coast of North America is meager. *Phascolosoma agassizii* is the dominant intertidal species from Kodiak, Alaska, to Point Conception, Calif. Its range extends to northern Baja California. *Ph. puntarenae* is its equivalent from Cape San Lucas to Panama. *Dendrostomum pyroides* occurs from Coos Bay, Oreg., to northern Baja California, while *D. dyscritum* has been taken between Point Conception and the northern boundary of California. *D. zostericolum* has been found from Point Conception to Ensenada, Baja California. *D. perimeces*, a consistent inhabitant of sandy mud, probably colonizes estuaries and sloughs from an off-shore, shallow-water population. It has been taken between Bodega Head and Venice, Calif. *D. hexadactylum*, which resembles *pyroides*, has been found only in 10 to 20 fathoms, in Monterey Bay. It was described from Japanese waters. The conspicuously large *Siphonosoma ingens* is a southern California species, extending north to Monterey Bay. *Sipunculus nudus* is an off-shore cosmopolite, which finds its way into estuaries of southern California and into the intertidal zone of Baja California and the Mexican coast. The genus *Golfingia* (formerly *Phascolosoma*) is a negligible element in the shore

fauna of California, only three inconspicuous species having been found: *G. margaritacea californiensis*, *G. hespera*, and *G. macginitiei*, all rare or very local in occurrence.

Only two sipunculids are known from Alaska: *Golfingia margaritacea* (Sitka, Kilisnoo, Dutch Harbor, Point Barrow) and *Phascolosoma agassizii* (Cape Fox, Prince William Sound, Kodiak). Undoubtedly *G. vulgaris* occurs in shallow water.

Phascolosoma agassizii has been taken from intertidal stations on Vancouver Island and the Queen Charlotte Islands, British Columbia, and *G. margaritacea* has been taken at Vancouver Island.

Washington has four species, all from Puget Sound and vicinity: *Golfingia vulgaris*, *G. margaritacea*, *G. pugettensis*, and *Phascolosoma agassizii*.

Two species are known from Oregon (Coos Bay): *Dendrostomum pyroides* and *Phascolosoma agassizii*.

With this unimpressive showing, I need hardly emphasize that this paper is not a definitive treatment of the fauna. While it is improbable that many new intertidal forms will come to light, it is equally probable that the list of shallow-water and deep-sea species is very far from complete.

In this paper I have used *Golfingia* Lankester in place of *Phascolosoma* authors and have replaced *Physcosoma* Selenka with *Phascolosoma* Leuckart in order to conform to accepted rules of nomenclature. For the same reason I have employed *Dendrostomum* Grube, the original spelling, instead of *Dendrostoma*, a later emendation by Keferstein.

KEY TO THE GENERA OF SIPUNCULOIDEA

a[1]. No horny or calcareous shield or cone at anterior end of trunk, although enlarged horny papillae and tubercles sometimes present in anal region.

b[1]. Tentacles surround mouth; tentacles few or many, simple or branched; nuchal organ, when present, dorsal to tentacles.

c[1]. Longitudinal muscle layer of wall of trunk divided into separate bundles.

d[1]. Skin of usually thick body wall provided with longitudinal coelomic canals or with independent coelomic pouches longitudinally arranged.

e[1]. Integumental coelomic spaces are longitudinal canals under cuticle; 4 retractors; intestinal coil with a long, anteriorly anchored loop; introvert with subtriangular scalelike papillae directed posteriorly. **Sipunculus** Linnaeus, 1766 (p. 375)

e[2]. Integumental coelomic spaces are in form of independent, usually irregular pockets arranged in longiseries; no accessory anterior loop in intestinal coil.

f[1]. Scalelike papillae on introvert; anterior to the 4 retractors are 2 small protractors arising in front of anus; irregular integumental coelomic spaces independent in each quadrilateral division of skin and sometimes with several long papillae; spindle muscle arises on rectum ----------**Xenosiphon** Fisher, 1947 (p. 377)

f^2. No scalelike papillae on introvert but rings of simple tiny spines; 2 retractors; skin strongly marked in rectangles; spindle muscle arises by 2 roots from body wall behind anus, and a third root is attached to esophagus; nuchal organ prominent; tentacular divisions of oral disk 8, the 2 ventral bifid; no Polian villi.
Siphonomecus Fisher, 1947

f^3. No scalelike papillae on introvert; skin not divided into rectangles by furrows; hooks or spinelets present or absent on introvert; 4 retractors; spindle muscle arises by 3 roots, a median in front of anus and 2 laterals behind anus; some species with incomplete transverse coelomic dissepiments; contractile vessel usually with Polian villi.....**Siphonosoma** [2] Spengel, 1912 (p. 380)

d^2. Body wall thin without coelomic canals or pockets.

e^1. Nephridia with prominent anterior lobe; spindle muscle with one root attached to body wall in front of anus and not anchored posteriorly; no Polian villi; tentacles very small, numerous, filiform; type with tiny complex hooks on introvert.
Siphonides, new genus (p. 386)

e^2. Nephridia not bilobed; contractile vessel with lateral pouches but no villi; no introvert hooks in adults.
Golfingia (subgenus **Phascolopsis** Fisher, 1950) (p. 393)

c^2. Longitudinal muscle layer of body wall forming a continuous layer, without separate bands (except *Phascolopsis* in *Golfingia*).

d^1. Anus in anterior part of trunk behind introvert.

e^1. Two nephridia; intestine forms a close spiral surrounding spindle muscle; 2 or 4 retractor muscles.

f^1. Tentacles relatively small, digitiform to filiform, few to many, in which case they are arranged in longitudinal double series radiating from circumoral disk.
Golfingia [3] Lankester, 1885 (p. 388)

f^2. Tentacles large, bushy, 4 to 8; retractors 2, rarely 4; contractile vessel with accessory tubules, usually conspicuously long, filiform.....**Dendrostomum** [4] Grube, 1859 (p. 404)

e^2. Only 1 nephridium, fixed by muscular threads; intestine not in close spiral but in loops extending forward and backward and held to body by several strands of muscle fiber; 1 to 3 retractor muscles; body often spirally twisted in adaptation to life in empty gastropod and scaphopod shells; single circle of tentacles.
Phascolion [5] Théel, 1875

d^2. Anus on introvert more or less in neighborhood of mouth; one retractor muscle, attached to posterior end of trunk; 1 nephridium; esophagus forms a few coils and passes into a short somewhat irregular spiral.
Onchnesoma Koren and Danielssen, 1875

---

[2] The coelomic pouches have not been verified for several small species and may be rudimentary or absent if body wall is thin, as in *Siphonides*. Small species with head retracted sometimes resemble *Golfingia*.

[3] *Phascolosoma* auct., nec Leuckart, 1828.

[4] *Dendrostoma* Keferstein, 1865.

[5] *Cryptosomum* Quatrefages, 1866.

b^2. Tentacles few to very numerous, arranged in a circle (interrupted dorsally), enclosing nuchal organ and situated dorsal to mouth; longitudinal muscle layer of trunk divided into separate anastomosing bundles; retractors 4, rarely 2; skin covered with papilliform glands which sometimes become tubercular in anal region and at posterior extremity.
Phascolosoma [6] Leuckart, 1828 (p. 422)

a^2. A specialized shield or cone present at anterior end of trunk.

b^1. A horny or calcareous shieldlike structure present at both ends of trunk; introvert arises on ventral side of anterior shield; longitudinal muscle layer continuous, or divided into bundles---**Aspidosiphon** Diesing, 1851

b^2. A hard, calcareous, cone-shaped appendage present at anterior end of trunk ventral to which is introvert; no posterior shield.
Lithacrosiphon Shipley, 1902

b^3. A round caplike structure made up of calcareous plates present at anterior end of trunk, from center of which the introvert is extruded; no posterior shield----------**Cloeosiphon** Grube, 1868

Genus SIPUNCULUS Linnaeus

Sipunculus LINNAEUS, 1766, p. 1,078. (Type, *S. nudus* Linnaeus.)

Diagnosis.—Usually large species with long cylindrical body and short, sharply differentiated introvert covered with squamiform papillae. Trunk generally thick walled, and longitudinal and circular muscle layers divided into regular fascicles. Skin divided into rectangular areas by longitudinal and circular furrows. Posterior end of body rounded or bluntly pointed and sometimes marked off from main trunk by a limiting ring fold of skin. A flat tentacular fold surrounds oral disk and from its margin tentacles of varying complexity develop. No hooks on introvert or papillae on the trunk.

Description.—The longitudinal muscle bundles rarely anastomose. Characteristic of the genus are longitudinal integumentary canals corresponding to the intervals between the muscle bundles and communicating with the coelom by slits between the regular circular fascicles of muscles that are external to the longitudinal. The canals contain coelomic fluid and anything floating in it. Retractor muscles four, separated to head; nephridia two; spindle muscle present or absent; a dorsal and a ventral contractile vessel without appendages; especially characteristic is an accessory intestinal spiral (pl. 18, fig. 1, A) between the end of esophagus and the beginning of the true spire, and coiled in the latter. Esophagus and intestine anchored by very numerous fixing muscles. "A median-dorsal unpaired epithelial tube opens upon the surface of the head immediately behind the tentacular fold, and leads backward to a cerebral sense organ anterior

[6] The genus erroneously called *Physcosoma* Selenka, 1897.

and ventral to the brain. The esophageal connectives do not surround the attachments of the retractor muscles to the head, as in most sipunculids, but lie behind and beneath these attachments" (Gerould, 1913, p. 427). The brain is conspicuous. On its front is a conspicuous cerebral organ or frons, sometimes elaborately lobed (Fisher, 1947, pl. 10, fig. 2; pl. 11, fig. 3). The ventral nerve cord is not attached anteriorly by a mesentery to the wall of the introvert, as in *Siphonosoma*. It is supported on each side by a strong paraneural muscle originating from the first, or first and second, muscle bundles just posterior to beginning of introvert.

Remarks.—Plate 18, figure 1, shows the accessory intestinal spiral *A* dissociated from the regular spiral *B*. This is easily accomplished by clipping the fixing muscles that hold it in place. I have figured (Fisher, 1947, pls. 10, 11) this extra spiral in situ in *Sipunculus polymyotus* and S. *galapagensis*, where the bends *X* and *Y* are indicated. The details of the fixing muscles are so different in these two species as to suggest that they may be of value in classification.

The accessory spiral is not present in *Xenosiphon* or in *Siphonosoma*.

SIPUNCULUS NUDUS Linnaeus

PLATE 18

Sipunculus nudus LINNAEUS, 1766, p. 1,078.

Remarks.—This is perhaps the best known and certainly one of the most widely distributed species of sipunculids—a truly eurythermal type. On the west coast of America it occurs from Monterey Bay, Calif., to Panama. It is found on the coast of Brazil, in the West Indies, and north to Beaufort, N. C. In Europe it inhabits the North Sea, English Channel, and the Mediterranean and Adriatic Seas. It is reported from the Red Sea, Indian Ocean, East Indies, China, Japan, along the western part of the Pacific (Yap, Loyalty Islands), and South Australia.[7]

The specimens recorded below have 30 to 33 muscle bundles. The ventral retractor muscles arise from longitudinal muscles 1–7, 1–6, or 2–5 (Ensenada); the dorsal retractors arise from 9–15, 10–14, 10–15, 11–16. A large specimen from southern California is 190 mm. long, but others are considerably smaller, circa 130 mm. The longest specimen is 290 mm. and was washed ashore at Pacific Grove, Calif., during a heavy surf.

The species has not been found at Monterey Bay in intertidal situations, even at Elkhorn Slough, which has been rather thoroughly explored by Prof. G. E. MacGinitie and others; but it occurs in subtidal situations, since many were washed ashore during a period of spring tides and heavy surf. It seems probable that Newport Bay

[7] A specimen sent me by S. J. Edmonds from Port Willunga, south of Adelaide, South Australia, is superficially like *S. nudus* but belongs to another, probably new, species.

and Anaheim Slough, in southern California, were colonized by an off-shore population, as was the Estero de Punta Banda, south of Ensenada. Professor MacGinitie took it also at a lagoon, Miramar Beach, Guaymas, Mexico, while Ricketts established a record at La Paz.

Specimens examined.—Thirty-five, as follows:

Guaymas, Mexico, lagoon at Miramar Beach, Feb. 9, 1948, G. E. MacGinitie, 1 specimen.

El Mogote, Baja California, near La Paz, March 22, 1940, E. F. Ricketts, 1 specimen.

Estero de Punta Banda, Baja California, 6 miles south of Ensenada, Dec. 19, 1930, sand, G. E. MacGinitie, 5 specimens.

Anaheim Landing, Calif., March 1918, gravel, 2 specimens.

Newport Bay, Calif., January to February 1930, G. E. MacGinitie, 20 specimens.

Pacific Grove, Calif., Jan. 6, 1939, washed ashore by high seas, 6 specimens.

Genus XENOSIPHON Fisher

Xenosiphon Fisher, 1947, p. 360. (Type, *Sipunculus branchiatus* W. Fischer.)

Diagnosis.—Differing from *Sipunculus* sensu stricto in the following particulars: Integumental coelomic spaces in the form of independent sacs of irregular outline; an extra pair of muscles functioning as retractors and protractors arising from posterior border of introvert and inserted in front of brain; rectum unusually long, the anus being in front of nephridiopores; postesophageal intestine without a long forward loop; nephridia long, slender, attached to body wall for nearly their entire length; squamiform papillae of very short introvert increasing in size toward the tentacles, which have very many leaflets arranged in subtriangular pads surrounding the mouth; type species with papilliform dermal outgrowths.

XENOSIPHON BRANCHIATUM (Fischer)

Plate 19

Sipunculus mundanus var. *branchiatus* W. Fischer, 1895, p. 3, pl. 1, figs. 1, 1a, 2.
Sipunculus branchiatus Spengel, 1913, p. 74.
Xenosiphon branchiatum Fisher, 1947, p. 360, pl. 12.

Description.—The following description is based chiefly on three specimens from Panama. Length 310 mm.; introvert and tentacle crown 20–25 mm.; thickness of cylindrical body 8–12 mm., this varying according to constriction of ring muscles. The specimen from La Paz, 420 mm. long, is constricted in the middle of body to 8 mm. diameter. Longitudinal muscle bands 29–34, only rarely anastomosing. When the body is fully inflated the longitudinal and circular muscles divide the surface into flat rectangular areas separated by rather inconspicuous grooves, but when constriction takes place there is apparent a series of more or less convex annuli. The middle third of the body, except for a ventral zone, about six muscle bands in width,

is closely covered with slender pointed papilliform outgrowths of the cuticle, 1–1.5 mm. long, which give a furry appearance to skin. These papillae communicate with irregularly zigzag subcutaneous canals, above which the cuticle usually forms slight welts, which have a direction oblique to the longitudinal axis of the dermal rectangles. Each rectangle has its own canal, independent of the others (pl. 19, figs. 4, 5). Beyond the papuliferous area these canals—or more properly spaces, as they are usually branched—can be traced forward half the distance to the head, and also posteriorly, as they are often self-injected with yellowish material from the coelom. On the periphery of the papuliferous area a papilla usually appears, first at the anterior end of the canal, next at the posterior end, then in between, until there are four or five to each rectangle. Brown or yellow, finely divided material, which is sometimes loose in the canals, is also found in the bottom of the papillae. If the top of the canal is stripped off, a pore at either end is seen to lead deeper into the tissue (arrows in pl. 19, fig. 4). If ordinary ink is forced *from the coelomic side* into the pores that exist at intersection of longitudinal and transverse muscle bands, it appears in these pores at the ends of the subcutaneous canals but is usually blocked by material already in the canal. The papillae are highly iridescent in sunlight. The area strongly reminds one of the papularium of a sea star, and the function is probably the same, i. e., respiratory.

The terminal knob of the body is very short, broadly rounded to subtruncate, and the slight margin is capable of disappearing under distension. There is a conspicuous terminal pore, and the skin, either smooth or longitudinally ridged, is closely beset with microscopic pores of at least two sizes.

The short introvert is covered with squamiform papillae, which increase in size toward the front, near which they decrease over a narrow zone to the bare zone behind the tentacles. The largest papillae are 0.75–1 mm. in length and breadth.

The tentacles are composed of very numerous small grooved foliate elements in subtriangular mats or groups, radiating from the mouth, which is ventral to the center. There are seven of these from which ridges of tissue converge to the mouth, two dorsolateral, two lateral, and two ventral, the odd one being the middorsal and much the largest. On the periphery of the crown the space between the major groups is filled in with one to three small groups of tentacles, which probably increase in number as growth proceeds.

The anus is equivalent to about five muscle rings (not clearly differentiated) behind the posterior papillae of the introvert.

Interiorly the longitudinal muscles form flat bands becoming angular in section only when the body is much constricted. The

introvert and the four retractors occupy about one-seventh of the body length. The retractors are free from one another and arise at approximately the same level. Both ventrals arise from muscles 1–4, while both dorsals arise obliquely from muscles 7–11. The two protractors arise from muscles 12–15 at the posterior border of the introvert. Before insertion, 4 mm. in front of the brain, they pass over the dorsal retractors. Their form and position, with the introvert out and in, are shown in plate 19, figures 1 and 2. The rectum passes far forward and opens close behind the (dorsal) origin of the protractors. (Muscles 17 and 18 are the two middorsal in figure 1; 18 and 19 are really 17 and 16 of the left side.) The rectum lacks thin, fan-shaped wing muscles. A slender spindle muscle arises from the ventral wall of rectum, 20-24 mm. behind anus; two roots proceed toward anus in the wall of the rectum, while the free muscle proceeds backward following the gut; 10–12 mm. from its origin is a very small coecum to which it is attached. The rectum is fastened dorsally to the body wall by a continuous mesentery, as far back as the two lateral anchors just behind the origin of the spindle muscle. These short lateral strands of tissue fan out slightly and may be rudiments of the rectal wing muscle. At any rate, to them are attached the ends of a delicate filament, forming a loop, which on each side passes obliquely ventralward along the origin of the dorsal retractors Here the thread is thickly beset with delicate racemose structures (poorly preserved). These quickly thin out posterior to the muscles and the rather long posterior loop is very delicate, translucent, and more loosely attached to the coelomic epithelium. Probably the "bandformiges Organ" figured by Selenka (1883, p. 109, pl. 12, fig. 174, y) in *S. mundanus* is a fragment of a similar structure. It resembles a gonad, but may be a more extensive "Zottenbildung."

The alimentary canal is macerated, but it appears to lack the forward loop that complicates the anterior end of the spiral of typical *Sipunculus*. Although in plate 19, figure 1, the esophagus is drawn to the right, it naturally turns to the left, for its first attachment to the dorsal wall is by separate fixing muscles, along muscle band 9 (or 8) of the *left* side. The mesentery between the esophagus and the left dorsal retractor extends posteriorly only about half as far as the right. This shorter left mesentery allows the ventral vessel to become sinistral, while the dorsal vessel gradually becomes dextral. Both end dorsolaterally at the beginning of the dorsal fixing muscles. From here the alimentary canal passes backward along muscle 9, for an unknown distance, before starting the spiral. The spirals are well established in the posterior half of the body.

Nephridia are long, slender, and except for a short terminal portion are closely attached to muscle 5.

The nerve cord is slender, less than half the width of muscle 1. Anteriorly the rather slender paraneural muscles arise from muscle 1, 4–5 mm. behind nephrostome. The bilobed cerebral ganglion has across the front a prominent frons (cerebral organ) composed of short bushy elements, exactly resembling a very tiny cauliflower.

Color in alcohol faded yellowish; the La Paz specimen is gray varied with straw color.

Type locality.—Esmeraldas, Ecuador.

Distribution.—Ecuador to La Paz, Baja California.

Specimens examined.—Four, as follows:

La Paz, Baja California, Lyman Belding, 1 specimen.
Panama, Hassler Expedition, 3 specimens.

Remarks.—So far as I know there is no record of this species from the region between Panama and La Paz. Its capture at La Paz by Lyman Belding, a pioneer ornithologist of California, illustrates amateur's luck, for E. F. Ricketts, collecting extensively in that locality in 1940, did not find it.

Genus SIPHONOSOMA Spengel

Siphonosoma Spengel, 1912, p. 264 (type, *Sipunculus australis* Keferstein).—Gerould, 1913, p. 432.—Fisher, 1950b, p. 805.

Diagnosis.—Size usually large; body resembling that of *Sipunculus*, while head and introvert suggest *Golfingia;* longitudinal muscle layer always separated into bands, the circular layer into distinct anastomosing fascicles (in most species); larger species provided with integumental coelomic sacs (instead of longitudinal canals of *Sipunculus*); four retractor muscles; a simple intestinal spiral anchored posteriorly by spindle muscle, which has three anterior roots; only the dorsal contractile vessel present, usually with very many Polian villi; two nephridia with large crescentic nephrostomes; paraneural muscles of ventral nerve cord less well developed than in *Sipunculus*, the cord for some distance back of head being fastened to body wall by a mesentery; tentacles filiform, or acute digitiform when contracted, numerous, arranged as in *Golfingia*, and forming a rather dense cephalic cluster; no *conspicuous* scalelike papillae on introvert.

Remarks.—Spengel separated this group from *Sipunculus* mainly on the basis of the integumental coelomic spaces, longitudinally arranged, which are not continuous, long canals as in *Sipunculus* but are small blind sacs showing characteristic forms in different species. He pointed to other differences such as the spindle muscle, the large semilunar nephrostome, attachment of nerve cord in anterior part of introvert, the presence of thick glandular epithelium in the wall of the rectum, structure of the tentacles, and the absence of scalelike papillae on the introvert. Spengel was rather fascinated by the integumental coelomic pouches. While these are fundamental struc-

tures, they are of little value in determining species and are perhaps absent in small species having a thin body wall.

The genus contains about 24 nominal species, which fall into 3 fairly natural groups: Subgenus *Siphonosoma*, sensu stricto (p. 381); subgenus *Hesperosiphon* Fisher (p. 386); subgenus *Dasmosiphon* Fisher (p. 386).

Subgenus SIPHONOSOMA, sensu stricto

Diagnosis.—No dissepiments in body cavity; rectum devoid of numerous elongate diverticula. The following species are included:

Spinelets on introvert	Devoid of spinelets on introvert
arcassonense (Cuenot).	*amamiense* (Ikeda).
australe (Keferstein), type.	*boholense* (Semper).
eniwetoki Fisher.[8]	*bonhouri* (Hérubel).
pescadolense Sato.	*dayi* Stephen.
takasukii Sato.	*funafuti* (Shipley).
	ingens (Fisher).
	mourense Sato.
	novae-pommeraniae Fischer.
	rotumanum (Shipley).

KEY TO SPECIES OF SUBGENUS SIPHONOSOMA LACKING SPINES ON INTROVERT

a^1. Retractors arise from body wall at same level; intestinal coecum present. **novae-pommeraniae Fischer**

a^2. Retractors arise at different levels.

b^1. Nephridia open on same level as anus or slightly in front; no intestinal coecum.

c^1. Muscle bundles 20 or more.

d^1. Small scalelike papillae on introvert ..... **dayi** Stephen

d^2. No scalelike papillae on introvert.

e^1. Circular muscles not divided into fascicles; fixing muscle anchors rectum ..... **mourense** Sato

e^2. Circular muscles divided into anastomosing fascicles; fixing muscle anchors esophagus ..... **ingens** (Fisher) (p. 382)

c^2. Muscle bundles 18 or less.

d^1. Dorsal retractors well developed, not very small.

e^1. Muscle bundles 14; skin glistening gray with certain blackish papillae scattered over surface becoming closely and regularly arranged on introvert; circular muscles in rings with numerous anastomoses; anus conspicuous; ventral retractors very long, originating from second and third longitudinal muscles; intestine with 30 to 40 coils; no fixing muscle? ..... **rotumanum** (Shipley)

---

[8] *Siphonosoma eniwetoki* Fisher, 1950b, p. 805.—Differing from *S. australe* (Keferstein) in having less prominent skin glands in anal region and at end of body; much smaller and blunter introvert hooks; thinner body wall; an esophageal fixing muscle attached to midventral line. Length of contracted specimen 105 mm., plus invaginated introvert, 35 mm.; thickness at middle of body 15 mm.; 16 to 18 rather broad longitudinal muscles, occasionally anastomosing; ventral retractors from muscles 2–3 or 2; the dorsals from 3–4; a fixing muscle to esophagus and one to rectum; intestinal coecum; nephridia small, free; color rosy gray. Type, U. S. N. M. No. 21128, Bogen Island, Eniwetok Lagoon, Marshall Islands, intertidal.

e^2. Muscle bundles 14 or 15, few anastomoses; body tapers posteriorly to a sharp tail; skin silvery white, rather transparent, with scattered papillae on body, but in rings near mouth; intestine with 8 to 12 coils; nephridia small, free; ventral retractors arise from two muscles, dorsals from one; no fixing muscle?.
funafuti (Shipley)

e^3. Muscle bundles 15 or 16; skin yellowish brown, deepest on introvert; surface rough, especially introvert base and end of body; ventral retractors from muscles 2 and 3 in middle of body, dorsals far more anteriorly from fourth muscle; fixing muscle, with 2 roots, is attached to esophagus; nephridia free, small, deep reddish brown; dorsal lip of nephrostome with 2 or more small processes.
amamiense (Ikeda)

d^3. Dorsal retractors very weak; ventrals long, arising at commencement of posterior third of body from a single longitudinal muscle; skin very thin with only a few papillae; 18 muscle bundles; intestinal spiral with 16 double loops; spindle muscle strong, with 2 anterior lateral anchors expanded at attachment to body wall; nephridia long, attached by anterior third, nephridiopores slightly behind anus.
bonhouri (Hérubel)

b^2. Nephridia open posterior to anus (fide Selenka); intestinal coecum present; 30 muscle bundles.....**boholense** (Semper)

SIPHONOSOMA INGENS (Fisher)

PLATES 20, 21

Siphonomecus ingens FISHER, 1947, p. 365, pls. 14, 15.

Diagnosis.—Size very large and body slender, either uniform in thickness or posterior portion contracted, with an attenuate extremity; introvert long; skin smooth, with numerous tiny roundish immersed glands, much fewer and smaller on introvert; longitudinal muscle layer of postintrovert region divided into 20–25 muscle bands, rarely anastomosing; circular layer split into anastomosing fascicles; four retractors, the dorsals arising well in front of ventrals, which are separated from nerve cord by two or three muscle bands; postretractor region about half body length; strong spindle muscle of *Siphonosoma* type arising in front of anus and attached at posterior end of body; intestinal spiral very long (60–62 coils); contractile vessel densely papillated posteriorly; nephridia free, opening a short distance in front of anus; small coelomic papillae forming a transverse zone in front of nephridia; tentacular crown capitate; tentacles arranged in 12 double meridional series, upward of 12 to a series; nuchal organ very small, at anterior end of dorsal double series. Length of type, fully relaxed, 500 mm.; diameter 8–10 mm.; introvert about 90 mm.; distance from head to nephridiopores 130 mm.; to anus 140 mm.; to attachment of ventral retractors 215 mm.; to end of intestinal spiral 435 mm. (unusually extended for preserved specimen).

Description.—The skin of the preserved specimens is pale yellow or muddy brown. It is closely beset with small, inconspicuous, roundish

glands, on the order of six to eight to each oblong rectangle, into which the skin is divided. These glands are immersed in the skin (which is smooth to touch) and are surrounded by the peripheral portion of the subdermal coelomic pockets. Coelomic fluid enters these irregular spaces by way of the narrow intervals between the circular muscle bands; stain forced into them indicates that the space just under the epidermis is independent for each rectangle. The annular and longitudinal grooves that outline the rectangles vary in depth with the inflation of the skin. The posterior end of specimens is likely to be very attenuate and pointed and the annuli conspicuous. On the introvert the glands are very tiny, fewer, and visible only in strong light.

The introvert is not especially well marked externally except by the absence of the glands, and it is the long portion characterized internally by the sievelike structure of the longitudinal muscle layer. There are no hooks.

The arrangement of tentacles is more easily understood in a small specimen than in the adult, where they are much longer (pl. 20, fig. 1). The crown, while reminiscent of *Golfingia gouldii*, differs in having the tentacles of all the double rows, especially the dorsal, *close together*, with the result that the nuchal organ is almost rudimentary. There are 12 of these double rows separated by 12 grooves: A dorsal double row (not more widely separated than the rest) reaches nearest to the mouth; opposite it is a midventral; on each side, five laterals. Counting clockwise from the dorsal, double rows 2, 4, 6, 8, 10, 12 do not reach quite so near the mouth as the alternates. The middorsal has 7 tentacles in each series in this small specimen, the others, 5 and 6 as a rule. In large specimens the tentacles are relatively about twice as long and 10 to 12 in *each* series. Large specimens would therefore have upward of 240 tentacles altogether. In the small specimen the inner end of the dorsal group of tentacles overlies the brain, which is visible through the skin. The *very small* nuchal organ is at the inner end of this dorsal group, well hidden by the first and second tentacles, and hence is close to the brain.

The inner longitudinal muscle layer is divided into 20 to 25 bundles, which anastomose infrequently. The regular bundles cease 20 to 25 mm. in front of the anus and anastomose every few millimeters, so that this layer from here to the head appears sievelike by reason of very numerous elongate pores. The intervals between the regular longitudinal muscles are crossed by the circular muscle bundles, which anastomose freely. The openings between the circular fascicles give entrance to the transverse lacunae, which in turn feed the subcutaneous spaces that surround the skin glands. In the posterior third of the body the longitudinal muscle bundles change from flat

ribbons to ridges, which are narrower than the intervals between. The circular muscle bundles are here seen to best advantage. The transverse slits between them are virtually very numerous pockets directly beneath the thin skin, to which the coelomic fluid and contents have access.

Posterior attachment of the ventral retractors is to muscle bundles 3–4, 4–5, 3–5, from nerve cord; that of dorsals is to muscle 8 or sometimes 7, well in advance of the ventrals. Anteriorly the four retractors are in close contact forming a muscular trough in which lies the esophagus. The lateral mesenteries of esophagus are apparent for only a short distance posteriorly.

The nephridia are slender, free, brown, and open about four muscle bands laterally from the nerve and a short distance (varying with contraction of longitudinal muscles) in front of the anus. In one specimen they are full of eggs. In front of the broad nephrostome, and also sometimes for a short distance back of it, is an area occupied by papilliform outgrowths of the epithelium, the so-called Keferstein bodies. They are either simple or branched (pl. 20, figs. 4, 5).

In the relaxed type specimen the esophagus is very long, slender, and anteriorly marked by the contractile vessel. The lateral mesenteries are inconspicuous and their posterior border has a muscular strand continued upon the sides of the esophagus. The contractile vessel is posteriorly densely papillated and its posterior end is considerably behind the point where the esophagus becomes attached to rectum. Just back of this point the esophagus has a special fixing muscle (F), which is anchored by a fork spanning the nerve cord well in front of the attachment of the ventral retractors. The special fixing muscle, F, sends a few strands to the rectum, which is here closely attached to the esophagus. The intestinal spiral (60 to 62 single coils) is very long and sometimes reaches nearly to the end of the body.

Plate 20, figure 3, and plate 21, figure 3, show the relationship of esophagus, rectum, and spindle muscle in the type and paratype. The spindle muscle arises in front of the anus and after passing backward through the intestinal spiral (which in the type extends to within 65 mm. of the end of body) it sends off numerous branches, which are attached to the longitudinal bands ventrally, laterally, and dorsally, while a small strand continues to the posterior extremity. At the point where the esophagus joins the rectum there are two symmetrical lateral roots (S^1, S^2) attached in front of the dorsal retractors to the first muscle bundle external to that from which the dorsal retractors arise. There is no coecum. The wing muscles are fairly conspicuous.

At the extreme posterior end of the body are four or five slender, terete, fusiform bodies, which open close together (around the end of

the spindle muscle), each on a slight pustule of the skin. They somewhat resemble a cluster of nematodes.

The brain measures about 1 mm. in length and is bilobed. It varies somewhat in appearance in different specimens by reason of being partly obscured by muscle fibers.

Young.—The above description applies to the mature specimens. Those under 125 mm. have a thinner body wall, translucent if at all inflated. Both longitudinal and circular muscle layers are thinner, but are subdivided into bundles, although the circular are sometimes difficult to see if the body wall is stretched by inflation. The circular bundles then flatten and close the stomata, which lead to the integumental coeca, and the layer appears to be continuous. In well-relaxed specimens the retractors are very slender, being narrower than the longitudinal bands of body wall. The Keferstein bodies are not present in two specimens measuring 80 and 110 mm., but are present in one 150 mm. long.

Type.—U.S.N.M. No. 20910, January 31 and July 18, 1931, and July 19, 1933, G. E. MacGinitie collector, 8 specimens.

Type locality.—Morro Bay, San Luis Obispo County, Calif.

Specimens examined.—From California:

Newport Bay, Orange County, January to February 1930, and Feb. 14, 1932 (with eggs), among *Zostera*, G. E. MacGinitie, 7 specimens.

Elkhorn Slough, off Monterey Bay, sandy mud, low tide, G. E. MacGinitie, 1 specimen.

Remarks.—*S. ingens* belongs in the subgenus *Siphonosoma,* in the section lacking spinelets on the introvert. It most nearly resembles *S. mourense* Sato (1930, p. 6, pl. 1, figs. 2–4), Mutsu Bay, Japan. It differs in having circular instead of elliptical skin glands; the circular muscle layer is divided into anastomosing fascicles; fixing muscle F anchors the esophagus primarily, and not the rectum; lateral roots S′ S″ of spindle muscle are anchored farther in advance of the dorsal retractors; nephridia open between muscle bands 4 and 5 instead of 3 and 4. Sato states that there are 30 coils in the intestinal spiral; if double coils are meant, the number is about the same as in *ingens.*

In *mourense* there are 22 longitudinal muscle bundles; the ventral retractors arise from muscle 3 and 4 and the dorsals from 8, 9, or 10 (8 in the figure). These are possible variations of *S. ingens.*

The genus *Siphonomecus*, in which I originally placed this species, is now restricted to the type, *S. multicinctus* Fisher. It differs from *Siphonosoma* in having only two retractors; a very conspicuous nuchal organ; eight pinnate tentacular groups, of which the two ventral are bifid distally; more complex integumental coelomic pockets; no Polian villi; and a spindle muscle with three roots but of a pattern entirely different from that of *Siphonosoma* (Fisher, 1947, p. 363, pl. 13).

Subgenus HESPEROSIPHON Fisher

Hesperosiphon FISHER, 1950b, p. 805.

Diagnosis.—No dissepiments in body cavity; numerous conspicuous diverticula on rectum. Three species are included:

No spinelets on introvert	Spinelets on introvert
vastum (Selenka and Bülow), type	*crassum* (Spengel) Fischer
	parvum Fischer

Subgenus DASMOSIPHON Fisher

Dasmosiphon FISHER, 1950b, p. 805.

Diagnosis.—Many transverse dissepiments attached to ventral wall of coelom; no diverticula on rectum; no introvert hooks. *Dasmosiphon* includes the following species:

billitonense (Sluiter)	*formosa* Sato
carolinense Spengel	*hataii* Sato
cumanense (Keferstein), type	*koreae* Sato
edule (Sluiter)	

SIPHONIDES, new genus

Diagnosis.—Resembling *Siphonosoma* but with simpler organization, lacking integumental pockets, Polian villi, the lateral roots of spindle muscle and its posterior attachment; nephridia strongly bilobed; no dissepiments; no Keferstein bodies; tentacles numerous, very small, filiform; type with minute, rather complex hooks on introvert.

Type.—*Siphonides rickettsi*, new species.

SIPHONIDES RICKETTSI, new species

PLATE 22

Diagnosis.—A slender, rather *Golfingia*-like species, having an introvert comprising about three-fourths total length; head very small; tentacles very numerous, filiform; 35 rings of minute slender hooks; skin with numerous mammiform glands; nephridia with two lobes; contractile vessel without villi; intestinal spiral free posteriorly; spindle muscle with only one root; 20 to 24 longitudinal muscle bundles; circular muscle layer continuous; no coelomic pouches in body wall, which is probably translucent in life; no dissepiments.

Description.—Length of type 170 mm., of which 135 mm. is in front of anus. The body is slender, 4 to 5 mm. thick, the introvert tapering to 1.25 mm. behind the tentacles, the crown of which, retracted, is 1 mm. high. The tentacles are very numerous, filiform, and appear to be arranged in concentric groups, closely packed. Behind them for a distance of 6 mm. are about 35 circles of minute slender hooks (0.05 mm. long), so closely packed that they touch. There are about 100 to each millimeter. The hook is very characteristic in having

at the base, on the incurved side, a comb of curved hooklets that are transparent, but brownish, like the hook. The hook rings are in tiny furrows separated by glandular ridges. The glands are immersed in the skin, 0.08 to 0.09 mm. by 0.04 to 0.05 mm., placed close together (the shorter diameter transverse), and each has a definite pore near the next aboral hook ring, 0.015 mm. in diameter.

The body is covered with spaced, small, mammiform glands surmounted by a more or less evident cylindrical papilla. In the type, probably caused by preservation, these are involved in transverse and longitudinal folds of the skin. These gradually decrease in size forward on introvert, where the skin folds become closely placed rings on which the glands, now tiny conical papillae, are borne.

The longitudinal muscles of the body wall in 20 to 26 rather broad bands, close together, flat when the body wall is inflated, and only occasionally anastomosing. These bands extend in front of the anus for a distance about half that between the anus and the posterior extremity, and forward of this the inner muscle layer is continuous, transversely crinkled like silk. The circular muscle layer is thin and not separated into bundles. Integumentary pockets absent. The retractor muscles are very slender; ventrals arising far forward, at about one-fifth the distance between the anus and end of the body, from muscle bundles 3 and 4; dorsals arising between anus and nephridiopores from muscles 2–3 left, 3 right, or 1–3 both sides (type). Forward of the nephridium, the dorsals and ventrals unite into a single muscle on each side of the slender esophagus. Spindle muscle starts forward of anus and follows usual course, but is not attached posteriorly; the two lateral roots, usually present in *Siphonosoma*, are absent. Fixing muscle F anchors ascending intestine to muscle bundle 1 left.

The nephridia are reddish brown, with a prominent anterior lobe, which may be short or long (up to one-third to one-half length of posterior lobe). The anterior lobe is sometimes turned posteriorly. Nephrostome: the lower part of the lip is attached to the body wall, the free part having slender lobes. The nephridium is attached obliquely for a short distance at base, and opens between muscles 4 and 5, or through a cleft on 4. No Keferstein bodies.

The esophagus is very slender, without fixing muscle. Intestinal spiral with about 20 double coils; a conspicuous coecum on rectum. The contractile vessel is very slender and without diverticula. The nerve cord in the anterior part of the introvert has a mesentery; farther back it is free except for the moorings by the lateral nerves. The gonad is at the origin of the ventral retractors.

Type.—U.S.N.M. No. 21224, from under boulders along with *Phascolosoma antillarum* and *Ph. puntarenae*, March 20, 1940, E. F. Ricketts collector, 2 specimens.

969586—52——2

Type locality.—Point Lobos, Espíritu Santo Island, near La Paz, Baja California.

Genus GOLFINGIA Lankester

Phascolosoma authors, not F. S. Leuckart, 1828.

Phascolosomum DIESING, 1851, p. 63, partim; 1859, p. 758, partim.

Phascolosoma KEFERSTEIN, 1862, p. 39, partim; 1865b, p. 422, partim.

Homalosoma KEFERSTEIN, 1865b, p. 436 (for *Phascolosoma margaritaceum* Sars). (Preoccupied by *Homalosoma* Wagler, 1850, and Agassiz, 1846.)

Petalostoma KEFERSTEIN, 1865b, p. 438. (Type, *Phascolosoma minutum* Keferstein.) (Preoccupied by *Petalostoma* von Lidth de Jeude, 1829, Recueil de figures des vers intestinaux . . ., Preface, p. 2.)

Phascolosomum QUATREFAGES, 1866, p. 616. (Type, *Ph. vulgaris* de Blainville.)

Stephanostoma DANIELSSEN and KOREN, 1880, p. 464. (Type, *S. hansenii* Danielssen and Koren.) (Preoccupied by *Stephanostoma* Lenz, 1802, *in* Joerdens, Entomologie und Helminthologie des menschlichen Körpers . . ., vol. 2, p. 29.)

Phascolosoma SELENKA and DE MAN, 1883, p. 15.

Golfingia LANKESTER, 1885, p. 469, pls. 55, 56. (Type, *G. macintoshii* Lankester = *Phascolosoma vulgare* de Blainville, teste Stephen, 1934, p. 169.)—FISHER, 1950a, p. 548.

Apionsoma SLUITER?, 1902, p. 42. (Type, *A. trichocephalus* Sluiter.)

Diagnosis.—Usually small or moderate sized, rather slender sipunculids having the longitudinal muscle layer continuous except in *G. gouldii*. Distinct finger-shaped, leaf-shaped, or filiform tentacles encircle mouth in one or more rows or in a series of longitudinal double rows, interrupted in median dorsal line by the ciliated nuchal organ; in a few cases tentacles reduced to a circumoral fold. Hooks may or may not be present on introvert. Four or only two (ventral) retractor muscles of introvert. Contractile Polian vessel in most cases simple but in subgenus *Thysanocardia* is covered with Polian villi, and also is sometimes rudimentary in species with few tentacles. Intestine forms a double spiral coil of several, or many, whorls around axial spindle muscle which originates close to rectum and only exceptionally anchors spiral to posterior end of trunk. The pair of nephridia hang free. A pair of photic tubes lead backward from surface of a cerebral sense organ into substance of cerebral ganglion. The bottom (or posterior, blind end) of each of these tubes, when pigmented, forms an "eye spot." (From Gerould, 1913, emended.)

Remarks.—It is unfortunate that the name *Phascalosoma*, long applied to this group, is applicable only to the genus later known as *Physcosoma*. The type of Leuckart's (1828) *Phascolosoma* is *Ph. granulatum* of the Mediterranean, which was transferred by Quatrefages (1866) to his new subgenus *Phymosomum*. This was emended to *Phymosoma* and given generic rank by Selenka (1883), who failed to notice or ignored the discrepancy. He included *Phascolosoma granulatum* Leuckart in the synonymy of "*Phymosoma granulatum*." *Phymosoma*, being preoccupied, was later changed by Selenka (1897) to *Physcosoma*.

Phascolosomum Diesing (1851) is obviously an emended spelling. In addition to *granulatum* he included species of *Golfingia* (*vulgaris*, *eremita*) and of *Phascolion* (*strombi*). As noted in the synonymy, *Petalostoma* and *Homalosoma* Keferstein (1865b) and *Stephanostoma* Danielssen and Koren (1880) are preoccupied and hence are not available. The only tenable name seems to be Lankester's *Golfingia*, commemorating a holiday with Professor MacIntosh at St. Andrews. The type, *G. macintoshii*, according to Dr. A. C. Stephen, is an example of *G. vulgaris* (de Blainville).

Dr. J. H. Gerould (in litt.) deplores the shift of the name *Phascolosoma* to the genus heretofore known as *Physcosoma*. He believes that Leuckart's brief diagnosis was intended to include smooth-skinned forms that would now be classified as *Golfingia*. This is the view entertained by Keferstein, who did not recognize the value of the fundamental difference in the head region that separates the two genera. It is axiomatic that the identity of a genus is fixed by the type species, and that the type may not be shifted later at the whim of a reviser. This transfer of types is the error that Quatrefages committed. All writers, including Gerould (1913), seem to have ignored the discrepancy that the type of *Phascolosoma* was currently in the younger genus *Physcosoma*.

This genus contains so many species that no apology is offered for the creation of subgenera. The lists of species under *Golfingia*, sensu stricto, and *Phascoloides* are not complete.

KEY TO SPECIES OF GOLFINGIA HEREIN DESCRIBED

a^1. Introvert very slender and more than five times length of trunk; retractors 4, united into a single column for most of their length; minute hooks on introvert; intestinal coil anchored posteriorly; small animals usually in association with *Mesochaetopterus* and *Cerianthus*.
hespera (Chamberlin) (p. 393)

a^2. Introvert not exceedingly long, seldom attaining three times length of trunk; sometimes less than trunk length; retractor muscles separated to head; intestinal coil not anchored posteriorly.

b^1. Four retractors; introvert less than half total body length.

c^1. Spinelets on anterior part of introvert; skin rough, dark brownish.
vulgaris (de Blainville) [9]

c^2. No spinelets or hooks on introvert; skin smooth, pale yellowish, or gray, translucent.. **margaritacea californiensis**, new subspecies (p. 392)

b^2. Two retractor muscles; no Polian villi on contractile vessel; nephridia opening on same level as anus; retractors arising near middle of trunk.

c^1. Introvert about one-third total length armed with nearly straight brown spinelets; no fixing muscles; contractile vessel rudimentary; related to *G. abyssorum*.....**laetmophila**, new species (p. 397)

c^2. No spinelets or hooks on introvert.

d^1. Retractors weak; one fixing muscle; contractile vessel rudimentary.
eremita californica, new subspecies (p. 396)

[9] This species has not been taken in California waters. I have one specimen dredged near Friday Harbor, Wash., 25 to 60 fathoms, by Mrs. Ida Oldroyd, July 1917.

d^2. Retractors strong; seven fixing muscles; a well-developed contractile vessel ..... **elachea**, new species (p. 399)

b^3. Two retractor muscles; contractile vessel with numerous branched Polian villi.

c^1. Introvert nearly three-fourths total length.

d^1. Polian villi absent from anterior part of contractile vessel; one fixing muscle ..... **procera** (Möbius) (p. 402)

d^2. Polian villi extend entire length of contractile vessel; two fixing muscles ..... **macginitiei**, new species (p. 402)

c^2. Introvert about half total length; Polian villi not present on anterior portion of contractile vessel; one fixing muscle. **pugettensis**, new species (p. 401)

Subgenus GOLFINGIA, sensu stricto

Diagnosis.—Retractors 4; longitudinal muscle layer of body wall not divided into separate bundles; contractile vessel without villi; spindle muscle not attached to posterior end of body.

Type.—*G. vulgaris* (de Blainville).

No hooks on introvert	Hooks on introvert
anderssoni (Théel).	*cluthensis* (Stephen).
anguinea (Sluiter).	*cylindrata* (Keferstein).
appendiculata (Sato).	*elongata* (Keferstein).
capensis (Teuscher).	*muricaudata* (Southern).
charcoti (Hérubel).	*nordenskjöldi* (Théel).
glossipapillosa (Sato).	*ohlini* (Théel).
hudsoniana (Chamberlin).	*ownstoni* (Ikeda).
ikedai Fisher.[10]	*pudica* (Selenka).
margaritacea (Sars).[11]	*sanderi* (Collin).
noto (Sato).	*vulgaris* (de Blainville).[12]
okinoseana (Ikeda).	
signa (Sato).	
soyo (Sato).	
trybomi (Théel).	

[10] *Golfingia ikedai*, new name for *Phascolosoma japonicum* Ikeda, 1904, preoccupied by *Ph. japonicum* Grube, 1877 (*Physcosoma japonicum* authors) Fisher, 1950a, p. 550.

[11] Includes *Golfingia antarctica* (Michaelsen), *G. capsiforme* (Baird), *G. fusca* (Michaelsen), *G. georgiana* (Michaelsen), *G. hanseni* (Danielssen and Koren), *G. socia* (Lanchester). Probably *hudsoniana* is a form of this species.

[12] Includes *Golfingia papillosa* (Thompson), *G. harveii* (Forbes), *G. obscura* (Quatrefages), *G. lutea* (Théel), *G. dubia* (Théel), *G. valida* (Théel), and *G. macintoshii* Lankester.

GOLFINGIA MARGARITACEA (Sars)

PLATE 23, FIGURE 3

Sipunculus margaritaceus SARS, 1851, p. 196.

Phascolosoma margaritaceum KOREN and DANIELSSEN, 1877, Heft 3, p. 135, pl. 15, figs. 43, 44.—SELENKA, 1883, p. 25, pl. 4, fig. 37.—THÉEL, 1905, p. 63, pl. 3, figs. 29–33; pl. 4, figs. 34, 37; pl. 12, fig. 174; pl. 14, figs. 192–196; 1911, p. 26, pl. 2, fig. 20; pl. 5, figs. 67, 68.—GEROULD, 1913, p. 382.—WESENBERG-LUND, 1930, p. 25, pl. 3, figs. 33–36, 44; pl. 5, fig. 51; 1932, p. 5, fig. 3.—STEPHEN, 1941, p. 251, pl. 8, figs. 3, 4.—SATÔ, 1934, p. 5, figs. 5, 6, pl. 1, fig. 3.

Remarks.—This species has a bipolar distribution. In the Arctic it is circumpolar, ranging south in the Atlantic to south of Newport, 705 fathoms, and to Fayal Island, Azores (forma *meridionalis* (Gerould)). Forma *siberica* (Théel) occurs north of Asia and at Bering Strait, whence the species reaches Japanese waters (Sato, 1934, as var. *antarctica* (Michaelson)). On the American side the species was taken by the Harriman Alaska Expedition at Dutch Harbor, Unalaska, at the Shumagin Islands, at Kodiak Island, Kilisnoo, and Sitka. It has been dredged off Point Barrow by Prof. G. E. Mac Ginitie, from 152 to 741 feet. E. F. Ricketts has collected it at Sitka and at Rat Island, British Columbia, and it occurs at Friday Harbor, Wash.

The distribution in the Southern Hemisphere is summarized by Stephen (1941) as follows: Off Patagonia, Falkland Islands, South Georgia, Tierra del Fuego, Graham Region, Cape Andare, Port Charcot, Commonwealth Bay, Ross Sea. Théel (1911) made a critical study of material dredged by the Swedish Antarctic Expedition and was unable to establish any constant distinctions between Arctic and Antarctic specimens.

The synonymy of the species in its widest sense may be followed in Théel (1905, 1911); Wesenberg-Lund (1930); Stephen (1941).

The specimens from Alaska, British Columbia, and Washington seem to constitute a slight race, or form, differing from the typical. But if *Golfingia hanseni* and *G. trybomi* are to be considered as forms of *margaritacea*, it is best to refrain from adding another name to the list. This Alaskan form lacks the reticulated pigment at the end of the body reported by Sato as occurring in Japanese specimens. The papillae are less prominent, and the fixing muscle attached to rectum near anus (shown also by Théel, 1905, fig. 174) does not occur. In the Alaska specimens there are three to five fixing muscles. The typical number is four, which have a fairly constant pattern of attachment, although one may sometimes be missing or an extra one added (see pl. 23, fig. 3, and explanation.)

The small California form, however, cannot be lumped with the Alaska specimens. For typical *margaritacea* see Théel, 1905 and 1911, especially the beautiful figures drawn by G. Liljevall.

GOLFINGIA MARGARITACEA CALIFORNIENSIS, new subspecies

PLATE 23, FIGURES 1, 1, *a*, 2; PLATE 24, FIGURES 6–8

Diagnosis.—Size small, with a single ring of 16 tentacles (or fewer), slender body, no papillae, and the glands most prominent at posterior end of trunk and in a zone at base of introvert; two fixing muscles, F^1 anchoring esophagus to base of left dorsal retractor, and F^4 anchoring intestine (posterior to coecum) to right side between bases of right retractors; bases of dorsal retractors nearer together and coecum relatively much larger than in typical form; eggs much larger than in the Alaskan form. Skin nearly or quite opaque, pale yellowish brown. Length 9 mm. (introvert 3.5 mm.) to 19 mm. (introvert 8 mm.); breadth of trunk up to 2 mm. A living specimen attained 20 mm. in length.

Description.—In typical *Golfingia margaritacea* the number of tentacles increases with the size of the specimen. *G. m. californiensis* is at the stage shown by Théel (1905, fig. 196; typical form). His figure 194 (forma *sibirica*) is somewhat more advanced, but its broader circumoral disk and shorter tentacles are more like those of *californiensis*, which however has four larger and four smaller oral pads. Théel shows the nuchal organ with a single central furrow. *G. m. californiensis* has two furrows dividing the sensory cushion into three parts. *G. m.* forma *finmarckica* (the typical form), 20 mm. long, has 34 tentacles (Théel, 1905, p. 64) while forma *sibirica*, from Bering Strait, 35 mm. long, has only 16 tentacles. *G. m. californiensis* is more like *sibirica*, which likewise has more obtuse tentacles than the typical form. *G. m. sibirica* has "a thin almost transparent body wall, with hardly discernible reticulation." In *californiensis* the body wall is opaque except at anterior end of the introvert, where the skin is translucent and iridescent, and the reticulation is marked at the base of the introvert and the posterior end, where also the glands are prominent (pl. 24, fig. 8). The nephridiopores open at about the level of the anus or slightly in advance and are externally rather conspicuous for such a small animal.

The fixing muscles of *californiensis* are labeled F^1 and F^4, since they are evidently homologous with F^1 and F^4 of the Alaskan specimens. The relatively large coecum may be a characteristic of small specimens. In Alaskan examples 75 mm. long the coecum is rudimentary and the spindle muscle rather weak. In the California form it is rudimentary. The intestinal spire is long, with 30 to 32 single coils.

Although specimens of *californiensis* are small, the eggs are 0.34 to 0.35 mm. in diameter. In a slightly larger Alaskan specimen (Sitka) the eggs measure 0.25 mm. In an example from Dutch Harbor, Unalaska, 75 mm. long, they measure only 0.22 to 0.24 mm. in diameter.

Color in life pale yellowish brown; tentacles whitish; skin slightly translucent, that of introvert being iridescent.

Type.—U.S.N.M. No. 21220.

Type locality.—Pacific Grove, Monterey Bay, Calif.

Specimens examined.—From California:

Pacific Grove, Monterey Bay, Nov. 21 and Dec. 4, 1911 (eggs), W. F. Thompson.
Carmel Bay, low tide, in crevice of granite without sand, N. W. Riser, 1 specimen containing eggs.

Subgenus PHASCOLOPSIS Fisher

Phascolopsis FISHER, 1950a, p. 550. (Type, *Sipunculus gouldii* Pourtalès.)

Diagnosis.—Retractors 4; longitudinal muscle layer divided into separate bundles; spindle muscle not attached to posterior end of body; *Golfingia gouldii* (Pourtalès) only species.

Subgenus MITOSIPHON Fisher

Mitosiphon FISHER, 1950a, p. 550. (Type, *Phascolosoma hespera* Chamberlin.)

Diagnosis.—Retractors four; longitudinal muscle layer not divided into bundles; nephridia bilobed; spindle muscle attached to posterior end of body; introvert hooks with an accessory comb of spinelets at base.

Included species.—*Golfingia hespera* (Chamberlin), *G. misakiana* (Ikeda).

Remarks.—This small group differs from *Golfingia*, sensu stricto, in having nephridia with a prominent anterior lobe, in combination with a very long introvert and posteriorly anchored spindle muscle. The hooks are unlike any found in *Golfingia*, in having at their base a tiny comb of accessory teeth. The four retractors are united for most of their length into a muscular column, which, when the introvert is retracted, fills the body cavity with irregular coils. The tentacles are in a single series surrounding the mouth.

SYNOPSIS OF SPECIES OF SUBGENUS MITOSIPHON

a^1. Introvert 6 to 8 times length of trunk; coecum present; no fixing muscle; tentacles 12 to 20; end of hook moderately curved; about 7 slender denticles near base ..... **hespera** (Chamberlin) (p. 393)

a^2. Introvert about four times length of trunk; coecum absent; one fixing muscle; tentacles 8; end of hook abruptly curved, 4 or 5 coarser denticles near base ..... **misakiana** (Ikeda)

GOLFINGIA HESPERA (Chamberlin)

PLATE 24, FIGURES 1–5

Phascolosoma hespera CHAMBERLIN, 1919, p. 31.

Diagnosis —A small, slender species with long filiform introvert and slender, relatively short, fusiform body; 30 to 50 rings of very small hooks; very small tentacle crown; four retractors free for only a short distance; two large bilobed nephridia; no fixing muscles; *intestinal*

spire anchored posteriorly; no contractile vessel. Length of a typical fully relaxed specimen 140 mm.; anus (about in middle of trunk proper) to posterior end 13 mm.; diameter of trunk 1.5 mm.; of introvert 0.75 to 1 mm ; introvert 6 to 8 times length of trunk.

Description.—The body wall is thin, usually translucent, a bleached brown or yellow. The trunk is short, slender, and fusiform; the introvert is extremely long and filiform. At maximum retraction it entirely fills the body cavity with irregular coils, displacing the viscera. The introvert cannot be retracted as far as the nephridiopores or the anus, which is at about the middle of the trunk and posterior to nephridiopores. There is no sharp distinction between the trunk and the introvert. The posterior end of the body, which is often pointed, is thickly beset with short ovoid or cylindrical brown papillae, against a paler skin, 0.025 to 0.035 mm. in height and thickness. Overlapping the papilla zone and extending far along the introvert are much larger, transversely elliptical, pale brown glands, producing low conical eminences with a subcentral darker pore. They measure 0.28 by 0.1 mm. on the trunk and become somewhat smaller on the introvert, where they form a few not very regular longiseries. In specimens from Monterey Bay these glands are more conspicuous than in southern examples. When the specimen is well relaxed and fixed, the glands are low conical with pointed apex and darker than the general skin, even on the introvert, where they also are alined as more prominent parts of successive ring welts. The skin, in addition, is marked by numerous fine transverse furrows and at the posterior end of the trunk by longitudinal ones.

Only two Monterey specimens are well enough expanded to show the head region. The tentacular crown is very small, about 0.25 mm. in diameter, in one specimen surrounded by a collar but not in the second. The exact number of short filiform tentacles cannot be determined, but it is between 12 and 20 (pl. 24, fig. 4). A short distance back of the tentacles is a zone of tiny hooks. They form 20 to 50 very regular rings, are close together, and unless the skin is taut they lie in furrows separated by ridges. The hooks average 0.02 mm. in height, are curved, and on the posterior margin near the base there is a comb of slightly curved thorns. This hook zone occupies only 3 mm. of the very long introvert and is therefore visible only in fully extended specimens.

There are four retractor muscles (not two only as Chamberlin states). They are small and originate on about the same level as the anus, the dorsals as far as possible in front of the ventrals. As shown (pl. 24, fig. 2), they soon unite into a solid muscular column, which proceeds to the head. Along the dorsal side of this, and securely fastened to it, runs the esophagus. There is only a short segment between the end of the esophagus and the beginning of the in-

testinal spiral, which has 30 single coils and is anchored posteriorly by the spindle muscle. The rectum is bent forward and anchored to the dorsal body wall nearly as far as the coecum by a mesentery, along the free edge of which runs the inconspicuous spindle muscle. There are no fixing muscles and the wing muscles are small.

When filled with sex products the two nephridia are very large and each has a long anterior lobe. They open at a conspicuous distance in front of the anus, and the nephrostome has two semicircular lips.

I am unable to find any contractile vessel.

Type.—In the Museum of Comparative Zoology.

Type locality.—Balboa, Newport Bay, Orange County, Calif.

Distribution.—Monterey Bay to Gulf of California.

Specimens examined.—As follows:

Pacific Grove, Monterey Bay, Calif., 1911, W. F. Thompson, 10 specimens.

Newport Bay, Calif., numerous specimens collected at Balboa (mud flats) and Corona del Mar (beach), August 1929, February 1930 and 1933, by G. E. MacGinitie.

Laguna Beach, Calif., September 1917, on "eel grass," 2 paratypes.

San Lucas Cove, south of Santa Rosalia, on gulf coast of Baja California, "commensal in tubes of *Cerianthus*," March 24, 1941, E. F. Ricketts, 19 specimens.

Remarks.—Professor MacGinitie's specimens were found along the outside of the tubes of *Mesochaetopterus* sp.; those collected by Mr. Ricketts were commensal within the tubes of *Cerianthus*. The dissected specimen, with nephridia distended by sperm, was collected in August 1929. *Golfingia misakiana* lives under seaweeds covering a tufaceous sandstone between tide marks, Misaki, Japan (Ikeda, 1904, p. 7, figs. 3, 30–33).

Subgenus PHASCOLOIDES Fisher

Phascoloides FISHER, 1950a, p. 550. (Type, *Sipunculus eremita* Sars.)

Diagnosis.—Retractors two; contractile vessel without villi; longitudinal muscle layer not divided; nephridia without anterior lobe; hooks without accessory spines; spindle muscle not attached to posterior end of body.

No hooks on introvert

abyssorum (Koren and Danielssen)
depressa (Sluiter)
elachea Fisher
eremita (Sars)
filiformis (Sluiter)
fimbriata (Sluiter)
flagrifera (Selenka)
glacialis (Koren and Danielssen)
glauca (Lanchester)
laetmophila Fisher
liljeborgi (Danielssen and Koren)
macra (Sluiter)
mucida (Sluiter)
novaezealandiae (Benham)
prioki (Sluiter)
rutilofusca (Fischer) [13]
verrilli (Gerould)

[13] *Aspidosiphon rutilofuscus* Fischer, Zool. Anz., vol. 48, p. 97, 1916 (synonym, *Phascolosoma aspidosiphonoides* Fischer, 1922c, p. 11, pl. 2, fig. 8).

Hooks on introvert

benhami (Stephen)
chuni (Fischer)
cincta (Gerould)
cinerea (Gerould)
confusa (Sluiter)
coriacea (Keferstein)
delagei (Hérubel)
intermedia (Southern)
improvisa (Théel)
minuta (Keferstein) [14]
papillifera (Keferstein)
pellucida (Keferstein)
recondita (Sluiter)
sluiteri (Ten Broeke)
subhamata (Sluiter)

GOLFINGIA EREMITA (Sars)

Sipunculus eremita SARS, 1851, p. 197.
Phascolosomum eremita DIESING, 1859, p. 760.
Phascolosoma eremita KOREN and DANIELSSEN, 1877, p. 134, pl. 15, fig. 45.—SELENKA, 1883, p. 35, pl. 5, figs. 54, 55.—THÉEL, 1905, p. 72, figs. 6–8, 173, 187.—GEROULD, 1913, p. 385, fig. 1, pl. 58, fig. 5.—WESENBERG-LUND, 1930, p. 28, pl. 5, figs. 53, 54; 1932, p. 6; 1937, p. 11.

Diagnosis.—Size small; body cylindrical, with bluntly rounded posterior end; introvert rather abruptly narrower, about two-thirds length of trunk; tentacular crown small (Théel, fig. 187) with 27 to 40 short, grooved tentacles; skin olive-brown, with fine circular creases and tiny brown papillae, rather more closely placed at end of body and in anal region. Retractors two, rather weak, arising in middle third of body and separated to head; fixing muscles variable, attached to esophagus, to rectum, or to both; spindle muscle not attached posteriorly, esophagus attached to retractors by well-developed mesenteries; a small rectal coecum; intestinal spire long, with numerous coils; contractile vessel present in north Atlantic forms; nephridia short, opening on level with anus.

GOLFINGA EREMITA CALIFORNICA, new subspecies

The California specimens have no functional contractile vessel except possibly for a very short distance back of the head, whereas both Gerould (1913) and Wesenberg-Lund (1930) state that it is present in North Atlantic specimens. Gerould's figure 1 shows a well-developed vessel. In two of my specimens there is a single fixing muscle on the right side in the position shown in Théel's figure 173, but it is attached to the rectum behind the coecum. A third specimen lacks this muscle but has a rather long fixing muscle, arising on the left side, attached to the esophagus by two branches. There is a strong spindle muscle (not present in Gerould's specimens), which is attached close behind the anus and fused with all rectum as far as the small coecum. The long intestinal spiral has about 55 single coils.

The specimens vary in length from 15 to 33 mm., and the introvert varies greatly; in one case, measured from anus, it is as long as the

[14] Includes *Golfingia johnstoni* (Forbes), *G. anceps* (Théel), *G. sabellariae* (Théel), and *G. sarsii* (Théel).

remainder of body. In another specimen a new introvert seems to have been in process of regeneration.

Type (G. e. californica).—U.S.N.M. No. 21218, 291–298 fathoms, gray mud, rocks, April 12, 1904, 10 specimens.

Type locality.—Albatross station 4421, off San Nicholas Island, Calif.

Distribution (Golfingia eremita).—Greenland, Spitzbergen, eastward to Nova Zembla and the Kara Sea, south on Scandinavian coast to Bodo, north of Arctic Circle; on eastern coast of North America, in shallow water as far as Massachusetts Bay, and in deeper water as far south as about 40° north latitude (Gerould, 1913). "It occurs usually at depths of less than 100 fathoms, though Théel records a specimen from Umanak, Greenland, from 200 fathoms, and it has been found south of Cape Cod in 480 and 1,098 fathoms." (Gerould, 1913, p. 386.)

Benham (1922, p. 17) has described var. *australis* from Commonwealth Bay, Wilkes Land, in the Antarctic.

It has not heretofore been recorded from the north Pacific.

GOLFINGIA LAETMOPHILA, new species

PLATE 25, FIGURES 4–6

Diagnosis.—Related to *Golfingia abyssorum* (Koren and Danielssen) (Théel, 1905, p. 78). Differs in having papillae at posterior end of body, glandular papillae on introvert, entirely different hooks, better developed and more numerous tentacles, abnormally large wing muscles. Trunk cylindrical, fairly plump; introvert about one-third body length; body wall translucent, a pronounced glandular zone in front of anus, probably also tiny papillae; anterior part of introvert papillose, including dark-brown, blunt spinelets not in definite rings; retractors two, arising in middle of trunk; no fixing muscles; small nephridia having lower lip of nephrostome folded and lobate; contractile vessel largely rudimentary.

Description.—Total length 56 mm., introvert 17 mm.; distance from anus to end of body 36 mm. The introvert does not include the anus but ends a short distance in front, marked by a constriction. The skin of the trunk is smooth except for some tiny papillae at the posterior extremity and a zone between the anus and the base of the introvert, where the skin is somewhat gelatinous and thickly beset with filiform glands perpendicular to surface. It is difficult to ascertain if these extend above the surface as papillae. The proximal half of the introvert has a thick glandular skin, the thickness accentuated by invagination, the first 4 mm. crowded with thick glandular papillae about 0.1 mm. high. About 2 mm. behind tentacles is a zone 1.5 mm. wide of dark-brown spinelets (pl. 25, fig. 6) not in definite rings and

closely surrounded by the thicker glandular papillae. These spinelets have a dark-brown granular cortical layer, which rubs off easily, and are 0.14 to 0.17 mm. long. They appear to be soft and flexible. The tentacles are rather short and grooved and are extensions of an oral fold thrown into about 8 angular groups—perhaps 30 to 40 tentacles in all. The contraction of the head and the softness of the tissue make it difficult to be exact.

The two retractors arise about midway between the base of the introvert and the end of the body and are distinct both above and below as far as the head, although the esophagus is attached to them for over four-fifths their length. The inner surface of the body wall has a satiny luster. There are no fixing muscles. The wing muscles are unusually large. The strong spindle muscle is attached immediately behind the anus and is fused to the wall of the rectum but does not extend beyond the intestinal spire. Well-developed mesenteries anchor the esophagus to the retractors.

The nephridia are small and open on nearly the same level as the anus. The nephrostome is characteristic. The dorsal lip is entire, but the ventral is thrown into folds with five or six marginal lobes.

The appearance of the esophagus as it leaves the support of the retractors is shown on plate 25, figure 5. The slight constrictions continue to the head. There is no rectal coecum and the spire contains many coils difficult to count, as the spindle muscle is contracted and has telescoped them.

The contractile vessel is functional for only a short distance behind the head. From here a very slender thread of tissue can be traced along the esophagus to where the vessel normally ends. It can be seen only under brilliant illumination.

Brain large with two eye spots only slightly pigmented.

Type.—U.S.N.M. No. 21219, 1,059 fathoms, green mud, March 22, 1904, one specimen.

Type locality.—*Albatross* station 4387, off San Diego, Calif., 32°32′40″ N., 118°04′20″ W.

Remarks.—It would have been difficult to place this species without the aid of Théel's (1905) work on Arctic sipunculids, to which the following page and figure citations refer.

While *Golfingia laetmophila* appears to belong to Théel's *G. abyssorum* section (p. 57) on account of the translucent skin of the trunk, few papillae, reduction of the contractile vessel, and presence of introvert spines, its tentacle crown is as well developed as that of *G. eremita* (fig. 187) or *G. margaritacea* (fig. 194). The exact number of tentacles is not diagnostic, as it increases with age. The tentacles of *abyssorum* (fig. 206) are much simpler, and while Wesenberg-Lund (1933, p. 9) found fewer and longer tentacles in a specimen from the

English Channel, Théel was dealing with the types. However, *laetmophila* differs from *eremita* in having a translucent body wall, introvert spines, much better developed wing muscles and in lacking fixing muscles (Théel, fig. 173).

Golfingia abyssorum is slenderer than *laetmophila;* it lacks the thick pulpy papillae of spinelet zone; the spinelets are of an entirely different form and lack the opaque brown cortical layer (figs. 71–75). Wesenberg-Lund (1933, p. 10, fig. 3) mentions fixing muscles in her specimen of *abyssorum* and her figure indicates a feebler development of wing muscles. She states also that the contractile vessel is absent.

GOLFINGIA ELACHEA, new species

PLATE 25, FIGURES 1–3

Diagnosis.—A small form belonging to section of subgenus having a very short introvert, no hooks, and nephridia opening behind functional introvert on same level as anus. Skin, including that of introvert, thickly beset with tiny brown pyriform papillae; introvert less than half length of trunk, from which it is separated by a shoulder; retractors stout, originating midway between anus and posterior extremity; *alimentary canal with seven fixing muscles.*

Description.—Length 17.5 mm.; trunk 12 mm. The introvert begins at the horizontal lines on plate 25, figure 1, where the body has a beveled shoulder, and is less than one-half the length of the trunk. Body wall thin but opaque except anterior part of introvert. Skin thickly covered with brown pyriform papillae of nearly uniform size on trunk (0.06 mm. high), becoming a little longer on the "shoulder" in front of the anus, but not differentiated into an anal zone (fig. 3). On the introvert the papillae are abruptly smaller and diminish slightly in size up to a narrow bare zone behind tentacles. On the middle of the introvert, the papillae are 0.035 to 0.04 mm. high (fig. 2). The papillae are invisible to the naked eye but give the skin surface a soft velvety texture. The tentacles are rather numerous, filiform, 0.8 to 0.9 mm. long by 0.07 mm. thick. A cluster of ventral tentacles are conspicuously shorter.

Retractors two, strong, arising midway between the anus and the posterior extremity, the inner margin near the nerve cord (the right closer than the left). Anteriorly they are narrow. The characteristic feature of the species is the large number of fixing muscles—at least 7 (fig. 1), of which F^1, F^3, F^4 arise from the dorsal body wall forward of the middle of the trunk; F^2 and F^5 from the ventral surface to the right of the nerve cord in front of the right retractor; F^6 and F^7 from the right side, about midway between the base of the retractor and the base of the nephridium. F^1 is attached to the esophagus at the terminus of the contractile vessel; F^2, F^3, and F^4 are attached to

the uppermost coil of the ascending intestine; F^5, F^6, F^7, anchor the intestinal spiral farther back. The spindle muscle is not attached posteriorly.

The first coil of the alimentary canal, beyond the end of the contractile vessel, has a ringed structure as if it functioned as a gizzard. The spiral is rather snarled but there are about 36 single coils. Well-developed mesenteries anchor the esophagus laterally to the retractors. A small coecum is present.

The nephridia open on the same level as the anus and are not long, reaching only to the origin of the retractors.

The contractile vessel is a simple blind tube without trace of villi. The brain is relatively large with two conspicuous pigment spots.

Color in alcohol a soft brown, lighter on the introvert.

Type.—U.S.N.M. No. 21214, March 20, 1940, E. F. Ricketts, 1 specimen.

Type locality.—Point Lobos, Espíritu Santo Island, near La Paz, Baja California.

Subgenus THYSANOCARDIA Fisher

Thysanocardia FISHER, 1950a, p. 551. (Type *Phascolosoma procerum* Möbius.)

Diagnosis.—Retractors two; contractile vessel with numerous simple or branched villi; no hooks; nephridiopores always in front of anus. Included species are:

catherinae (F. Müller)
hozawai (Sato)
hyugensis (Sato)
macginitiei Fisher
martensi (Collin)
nigra (Ikeda)
onagawa (Sato)
pavlenkoi? (Ostroumov)
procera (Möbius)
pugettensis Fisher
pyriformis (Lanchester)
semperi (Selenka and de Man)
zenibakensis (Ikeda)

Remarks.—The species of this section of *Golfingia* differ from all others in the possession of numerous villi, or blind tubules, either simple or branched, on the contractile vessel. There are two retractor muscles arising in the posterior third of the trunk. The nephridia always open anterior to the anus. Back of the tentacles is a zone of smooth thin skin bounded by a narrow collar. The skin is usually pale sepia and is provided with darker small cylindrical papillae. There are no hooks on the introvert.

G. pavlenkoi (Ostroumov, 1909, p. 323) probably belongs in this subgenus, as it is stated to be related to *G. semperi* and *G. nigra*. The résumé in German does not mention the villi of the contractile vessel. The introvert is one-and-one-third the length of the trunk; the trunk and introvert are uniformly covered with dark yellow papillae, having a short cylindrical or rounded conical form; no hooks;

two strong ventral retractors springing from anterior border of the posterior third of the trunk; one fixing muscle; two wholly free nephridia.

SYNOPSIS OF SPECIES OF SUBGENUS THYSANOCARDIA

a^1. Anus and nephridia do not open on introvert; esophagus lies between the two retractors to which it is attached.
- b^1. Introvert long, 2 to 4 times length of trunk.
  - c^1. Anus spaced from posterior extremity about one-fifth total length;[15] tentacles in 6 to 8 groups, relatively few; villi absent from anterior part of contractile vessel ..... **procera** (Möbius), 1875 (p. 402)
  - c^2. Anus spaced one-fourth to one-third total length from posterior extremity; tentacles numerous, in more than 8 groups.
    - d^1. Villi simple, rather sparse, present only on posterior part of contractile vessel, one fixing muscle ..... **nigra** (Ikeda), 1904
    - d^2. Villi thick, bushy, branched, present throughout entire length of contractile vessel; 2 fixing muscles ... **macginitiei**, new species (p. 402)
- b^2. Introvert short, less than twice trunk length.
  - c^1. Villi of contractile vessel very short and numerous; no coecum.
    - d^1. Tentacular crown a simple circle of tentacles . **hyugensis** (Sato), 1934
    - d^2. Tentacular crown complex, of many tentacles.
      - e^1. No fixing muscle ..... **hozawai** (Sato), 1937
      - e^2. Two fixing muscles ..... **catherinae** (F. Müller), 1867
  - c^2. Villi of conspicuous length, sometimes bushy and branched.
    - d^1. No fixing muscle; a diverticulum at end of esophagus; nephridia very long ..... **martensi** (Collin), 1901
    - d^2. One fixing muscle; villi absent from anterior part of contractile vessel.
      - e^1. Skin papillae visible to naked eye. **semperi** (Selenka and de Man), 1883
      - e^2. Skin papillae not visible to naked eye; apparently smooth. **pugettensis**, new species[16]
    - d^3. Three fixing muscles; villi present all along contractile vessel.
      - e^1. Papillae on introvert-base cylindrical, 0.05 mm. high. **zenibakensis** (Ikeda), 1924
      - e^2. Papillae club shaped, 0.12 mm. high ..... **onagawa** (Sato), 1937

a^2. Anus and nephridia open on base of introvert; esophagus free from retractors but anchored by a fixing muscle, attached posterior to origin of retractors. **pyriformis** (Lanchester), 1905

---

[15] This is the proportion given by Théel (1905, p. 71) and the same obtains with my specimens. Gerould (1913, p. 384) studied large specimens from off Marthas Vineyard, Mass. The largest measured 180 mm. total length; trunk behind anus, 75 mm. The introvert (105 mm.) is thus 1.4 the length of trunk, not 2.5 as Gerould states. It seems probable that these specimens are not true *procera*.

[16] GOLFINGIA PUGETTENSIS, new species

Diagnosis.—Nearly related to *G. semperi*, but with very inconspicuous dermal papillae which are not visible without a lens; introvert length of trunk or slightly more, but less than twice length; tentacles very numerous, filiform; papillae tiny, the largest 0.07 mm. long and others much smaller; skin light to dark sepia, finely wrinkled; retractors arising in posterior third of trunk; villi crowded, branched, similar to those of *macginitiei*, but confined to free part of esophagus and extending only a very short distance forward between retractors; a strong fixing muscle anchors posterior end of esophagus to dorsal wall (position of F^2 of *macginitiei*); coecum present; intestinal spiral with at least 48 single coils; nephridia rather short, free, opening in front of anus (distance varying with contraction of longitudinal muscles of body wall).

Color, sepia.

Type.—U.S.N.M. No. 21215, Trevor Kincaid, 8 specimens.

Type locality.—Dogfish Bay, Puget Sound, Wash. Also from San Juan Island, Wash., sandy mud, zero tide, D. L. Ray, 8 specimens.

To see the dermal papillae, a ×10 lens is required, whereas Selenka (1883, p. 9) states that in *semperi* the papillae of the entire body can be seen with the naked eye.

GOLFINGIA PROCERA (Möbius)

Phascolosoma procerum Möbius, 1875, p. 157, pl. 3, figs. 1–5.—Théel, 1905, p. 70 pl. 2, figs. 19–26; pl. 3, figs. 27–28; pl. 12, fig. 190.

Diagnosis.—Small, slender, grayish species with very long, slender introvert and crown of 28 to 40 delicate tentacles in six double rows; anus situated not far from posterior end of body, which often ends in a slender projection; two retractors arising near posterior end of body; posterior part of contractile vessel with numerous simple or bifid villi; nephridia opening in front of anus; one fixing muscle anchoring esophagus to body wall in front of anus; length 40 mm.; anus to posterior end of body 7 mm.; diameter of trunk near posterior end 2 mm.

Description.—The small size and condition of material precludes a full description. Reference should be made to Théel's account (1905, p. 70) and Liljevall's accompanying figures. I have had to depend upon Théel for the number of tentacles. There are possibly eight groups in my specimens. The skin is beset with minute papillae (Théel, fig. 24) capping translucent convexities. The villi are definitely confined to the posterior part of the contractile vessel as in the specimens Théel studied. Théel does not mention the fixing muscle, which is attached to the esophagus farther forward than F^1 in *Golfingia macginitiei*, and to the body wall in front of the anus, not posterior to it. I am not able to find a coecum but Wesenberg-Lund (1939, p. 20) verified its presence in Danish specimens.

Type locality.—Bass Rock, Firth of Forth, Scotland.

Distribution.—North Sea to Danish waters and west coast of Sweden, shallow; Irish waters; off Marthas Vinyard, Mass., 100 to 266 fathoms (see footnote 15).

Specimens examined.—As follows:

Albatross station 4548, Monterey Bay, Calif., 46 to 54 fathoms, coarse sand, shells, rocks, 6 specimens.

Remarks.—It is possible, of course, that these specimens represent a distinct form or race of the North Sea *procera*. More material is needed for a conclusion to be reached.

GOLFINGIA MACGINITIEI, new species

Plate 26

Diagnosis.—Introvert nearly 3 times trunk length; tentacles very numerous in 16 double series; body wall opaque; skin smooth but beset with very numerous minute papillae without differentiation in anal region; retractors attached at beginning of posterior third of trunk; 2 fixing muscles anchoring esophagus dorsally; more than 60 coils in intestinal spire; especially characteristic are dichotomously branched Polian villi in great numbers.

Description.—The introvert is partly invaginated; if fully extended, the animal would measure 92 mm. in total length; anus to posterior extremity 23 mm. or one-fourth total length; greatest width near the posterior end 5.5 mm. The body wall is rather thick, opaque; the skin is very glandular, uniformly smooth in appearance, but thickly beset with minute brown subclavate papillae, slightly larger posteriorly (0.06 mm. high). There is no special zone in the anal region, but about 10 mm. in front of the anus, and anterior to the nephridiopores, the papillae become considerably smaller and more crowded (0.1 mm. apart), one or two occupying a quadrilateral or irregular area defined by slight creases of the cuticle. Such areas are also to be seen on the trunk, where the papillae usually have a light circular zone at base, becoming transversely elliptical in front of the anus. In addition to the papillae, numerous skin glands open flush with the surface of the cuticle, the pores being of 2 or 3 sizes. Within a square, the sides of which are 0.5 mm., about 25 of these pores are present, and at each corner is a papilla.

Back of the tentacles is a zone of purple skin, free from papillae, the posterior border plicated. The tentacular crown is more voluminous than in such species as *G. gouldii*, although arranged on the same general plan of double series joined by a fold of tissue at the outer edge of the oral disk. There are 16 of these double series, each comprising about 40 tentacles 0.6 to 0.8 mm. long, with the exception of the middorsal double series. This extends nearly to the mouth, forming a loop to enclose the lanceolate nuchal organ. The extended part of this double series carries about 10 extra shorter nuchal tentacles.

The longitudinal muscle layer is smooth, lustrous, undivided. Retractors two, arising about two-thirds the distance from the anus to the posterior extremity. The base is broad, emarginated, and divided by a deep notch into two parts. The spindle muscle is unattached posteriorly. Fixing muscles F^1 and F^2 anchor the esophagus to the body wall. Nephridia short, opening 4 mm. in front of anus. The rectum has a well-developed coecum. The intestinal spiral is relatively large, comprising 68 single coils.

The contractile vessel accompanies the esophagus to the intestinal spiral and throughout its entire length is provided on each side with Polian villi of characteristic form and arrangement. Just back of the head for a short distance these villi are short, simple, cylindrical, blind tubules. Soon they are bifid at the tip and increase in number until the esophagus leaves the retractor muscles. Then they begin to branch dichotomously twice, then three or four times, and become aggregated in bunches (pl. 26, fig. 5), the branched villi being 0.5 to 0.8 mm. long. These clusters form dense masses along each side of the free esophagus between the retractors and the intestinal spiral.

969586—52——3

The vessel and villi are pale orange and are packed with hemispherical corpuscles, 0.01 mm. in diameter, having one side invaginated.

Type.—U.S.N.M. No. 21223, sandspit, in *Zostera*, January 1930, G. E. MacGinitie.

Type locality.—Newport Bay, Orange County, Calif.

Genus DENDROSTOMUM Grube

Dendrostomum Grube, *in* Grube and Oersted, 1859, p. 118.

Dendrostoma Keferstein, 1865a, p. 207 (emendation of *Dendrostomum*).—Authors since 1865.

Diagnosis.—Distinguishable from other sipunculoids by their four to eight conspicuous, often several times dichotomously branched, grooved tentacles, which carry numerous small tentacules, pinnately or palmately arranged. Oral disk with four primary food grooves, which branch to the tentacles; inner longitudinal muscle layer of body wall continuous, not separated into bands; usually two retractor muscles; a strong spindle muscle attached near anus but not posteriorly; typically three fixing muscles or intestinal anchors; two nephridia not anchored by mesentery; contractile vessel with a few to very many, long or short Polian tubules; hooks or spines on introvert present or absent.

Remarks.—The California Dendrostoma are all large species, and with the exception of *hexadactylum* are found between tide marks. *D. pyroides* lives by preference and attains greatest size in clefts of rocks, especially granite, where it apparently maintains a permanent residence, retreating far from the surface when the tide is out. *D. perimeces*, the longest of all, is an estuarine form dwelling in muddy sand. It also lives off shore in deeper than intertidal water. *D. zostericolum* is found among eelgrass roots and in sandy mud among rocks, in bays, and on the open coast. *D. dyscritum* has been encountered on the open coast in fissures of rock where mud and sand can accumulate and where the deeper parts may be black from sulphur compounds. It also occurs off shore.

It is difficult to describe the shape of these animals since, when alive, they can stretch their bodies to an astonishing degree. Even when killed "extended," with tentacles expanded, there is much variation. However, such species as *zostericolum* and *perimeces* are obviously longer than the others and assume a more cylindrical form when carefully killed, while *pyroides* and *dyscritum* are likely to be swollen posteriorly and hence are more pyriform.

The California species have bushy tentacles, branched dichotomously several times, although the branches of such dichotomy are not necessarily equal. A typical crown, drawn from life, is shown on plate 28, figure 1. In some extralimital species, e. g., *D. blandum*,

the tentacles are simpler. Each of the four primary tentacles divides into two elongate branches, along the sides of which the tentacules are arranged pinnately.

Most of the species I have examined have three or four short transverse muscle bands in front of the nephridia.

Under existing rules of nomenclature the correct name of this genus is not *Dendrostoma*, which is an emendation of Grube's earlier *Dendrostomum*.

KEY TO KNOWN SPECIES OF DENDROSTOMUM

a^1. Hooks or spines on introvert, or at its base; two retractor muscles.
  b^1. Polian tubules very long.
    c^1. Tentacles arising from 4 stems, branching dichotomously several times. **pyroides** Chamberlin
    c^2. Tentacles arising from 4 stems, each with 2 branches along which the ultimate tentacules are arranged pinnately; introvert papillae inconspicuous ---------- **blandum** Selenka and de Man
    c^3. Tentacles 4, somewhat palmate, divided into 2 or 3 stems, along which the ultimate tentacules are arranged; 6 tentacles according to Gerould, 1913 ---------- **alutaceum** Grube
    c^4. Tentacles 6 ---------- **hexadactylum** Sato
    c^5. Tentacles 8, divided each into 2 near base; spines at base of introvert only ---------- **spinifer** Sluiter
  b^2. Polian tubules very short.
    c^1. Polian tubules unbranched; tentacles 4; hooks 50± ---------- **minor** Ikeda
    c^2. Polian tubules branched; tentacles 5 or 6; hooks few. **signifer** var., Selenka and de Man
a^2. Hooks on introvert; 4 retractors; 6 tentacles ---------- **pinnifolium** Keferstein
a^3. No hooks on introvert; 2 retractors.
  b^1. Anus and nephridiopores on nearly same level.
    c^1. Polian tubules very long; 6 tentacles.
      d^1. Esophagus with numerous pointed protuberances on its wall arranged in long series; 4 intestinal fixing muscles; small species. **peruvianum** Collin
      d^2. Esophagus without pointed protuberances, fixing muscles 3 or less; large slender species.
        e^1. Intestinal spiral of moderate length, with less than 50 coils (usually 15 or 16 double coils); fixing muscles present; Polian tubules more than 10.
          f^1. Fixing muscle F^2 attached to postesophageal intestine; retractors attached one-fourth to one-third body length from end. **zostericolum** Chamberlin
          f^2. Fixing muscle F^2 attached to intestine; retractors attached one-fifth to one-sixth body length from end. **dyscritum**, new species
        e^2. Intestinal spiral very long with upward of 100 coils; fixing muscles usually absent; Polian tubules 9 or 10 ---------- **perimeces** Fisher
    c^2. Polian tubules very short.
      d^1. Tentacles 4; Polian tubules unbranched.
        e^1. With elliptical glands ---------- **ellipticum** Sato
        e^2. With circular glands ---------- **tropicum** Sato
      d^2. Tentacles 5 or 6; Polian tubules branched. **signifer** Selenka and de Man

b^2. Nephridiopores well spaced behind anus.
c^1. Polian tubules very long; retractors arise posteriorly.
d^1. Size small; gonads on surface of retractors near their origin; F^2 attached to intestine only ..... **lissum**, new species
d^2. Size large; gonad on body wall just back of origin of retractors; F^2 anchors both intestine and postesophageal gut. **schmitti**, new species
c^2. Polian tubules short; retractors arise in middle region of body; size large (230 mm. in length) ..... **dehamata** Kesteven
a^4. No hooks on introvert; 4 retractors; tentacles ?; contractile "vessel bears a band of very short contractile villi" ..... **stephensoni** Stephen

KEY TO SPECIES OF DENDROSTOMUM DESCRIBED IN THIS PAPER

a^1. Hooks or spinelets on introvert.
b^1. Tentacles arising from 4 roots; hooks smaller; fixing muscle F^2 attached to postesophageal intestine ..... **pyroides** Chamberlin (p. 406)
b^2. Tentacles arising from 6 roots, hooks larger; fixing muscle F^2 with one branch to postesophagus, the other to intestine, or to intestine only. **hexadactylum** Sato (p. 410)
a^2. Hooks absent from introvert.
b^1. Anus and nephridiopores on nearly same level; tentacles 6; upper lip larger than the other three; nuchal organ not longer than wide.
c^1. Intestinal spiral of moderate length with less than 50 coils; fixing muscles of alimentary canal present; skin glands of approximately same size.
d^1. Fixing muscle F^2 attached to postesophagus; retractors attached one-fourth to one-third body length from posterior end; nuchal organ wider than long ..... **zostericolum** Chamberlin (p. 411)
d^2. Fixing muscle F^2 attached to intestine; retractors attached one-fifth to one-sixth body length from end; nuchal organ not obviously wider than long ..... **dyscritum**, new species (p. 417)
c^2. Intestinal spiral very long with upward of 100 coils; fixing muscles usually absent; skin glands of two or three sizes. **perimeces** Fisher (p. 415)
b^2. Nephridiopores well spaced behind anus; tentacles 4; upper lip not conspicuously larger than others; nuchal organ longer than wide.
c^1. Size small; gonad on surface of retractors near origin; dorsal tentacles not conspicuously smaller than others; fixing muscle F^2 attached to intestine ..... **lissum**, new species (p. 419)
c^2. Size large; gonad on body wall just back of origin of retractors; F^2 anchors both the postesophagus and intestine with branches to each; dorsal tentacles much smaller than the others. **schmitti**, new species (p. 422)

DENDROSTOMUM PYROIDES Chamberlin

PLATE 27, FIGURES 1, 2; PLATE 28, FIGURE 2; PLATE 29

Dendrostoma pyroides CHAMBERLIN, 1919, p. 31.
Dendrostoma petraeum FISHER, 1928, p. 195, pl. 6, figs. 1, 1a, 1b, 2; pl. 7, fig. 2; pl. 8, figs. 1, 1a.
Dendrostoma blandum SATO, 1930, p. 27; 1939, p. 412.

Diagnosis.—Typically a large, elongate-pyriform species with smooth skin and a zone of from few to many small, usually curved,

dark-brown thorns occupying middle third of introvert, which is about one-third to one-half body length, depending upon degree of contraction; smooth zone back of tentacles broad, one-fourth to one-third of introvert, reddish brown to purple; no prominent papillae anywhere; tentacular crown strictly dendritic, starting with four major stems, each of which almost immediately divides into two or three branches, and these into others, the crown increasing in complexity with increasing size of animal; dorsal blood vessel with a network of accessory vessels and with numerous, sometimes branched, long blind Polian tubules.

Description.—This is one of the chunky pear-shaped Dendrostoma, apparently larger in central California than south of Point Conception. Ordinarily large specimens attain 120 mm., exclusive of tentacles, but these are small in comparison to an example collected at Bodega Head by Dr. D. M. Wootton. When alive, this giant was 195 mm. long, the introvert alone 50 mm.; thickness of trunk 30 mm.; of introvert 15 mm. The introvert is cylindrical, the anterior fourth to third a reddish brown to purplish glossy zone, marked by fine circular creases; at the posterior border of this collar is a strong sphincter sometimes indicated by a constriction and a narrow purple zone in preserved specimens. Immediately behind this the middle third of the introvert is occupied by dark brown, well spaced, prominent curved spines, directed posteriorly, their bases varying from 0.17 to 0.25 mm. in diameter, and their length from anterior edge of base 0.17 to 0.35 mm. Generally, the smaller the specimen the fewer the hooks. Basal third of the introvert is smooth; the surface of the trunk is superficially smooth, very finely and evenly peppered with minute brown spots of two or three sizes (0.07 to 0.1 mm. diameter) which are sometimes tiny eminences. These extend forward as far as the anterior border of the hook zone, but on the introvert are usually colorless.

Tentacles highly dendritic. Four food grooves lead from the mouth to as many groups of tentacles; each group consists of two main stems, between which a shorter branch sometimes assumes the proportions of a major division. Basically there are four tentacles, which by division close to base give the appearance of eight or nine. The tentacles do not give off secondary dendritic branches near the base as do those of *zostericolum*. Instead, the thin mobile margin of the groove, below the main branches, is produced at intervals into a few slender processes. A specimen 40 mm. long, from Ensenada, has the following number of terminal *branchlets* (bearing the ultimate tentacular elements): dorsal tentacles, 32 and 30; ventral, 26, 14. In big specimens the branchlets are much more numerous.

The two large retractors have their origin in a wide straight attachment at the middle of the posterior third of the body, the inner

border of the muscle arising close to the nerve cord; anteriorly they do not join until close to the head. The spindle muscle, inserted in the body wall dorsally just behind the anus, is free for a short distance and then is fused to the gut wall as far as the coecum, beyond which its attachment to the ascending spiral is by short muscular frenula. The descending spiral from the esophagus is attached to the ascending gut. Fixing muscles F^1, F^2, F^3 are rather similar to those of *zostericolum;* F^2 sometimes consists of three strands arising from the same point, or it starts as a single muscle and divides into two or three.

A slight constriction of the gut just posterior to the attachment of F^1 probably marks the end of the esophagus. In a large specimen there are about 30 coils of the intestine (15 or 16 double coils). Along the ascending gut is a conspicuous ciliated groove, terminating at the coecum.

The nephridia are free, very long, and attached to the body wall slightly behind the anus. They may reach to the posterior end of the body.

The contractile vessel gives off dorsolaterally numerous anastomosing branches, which form a network enclosing the esophagus, becoming more complex posteriorly. Usually a *midventral* vessel leaves this complex and runs far forward. For a short distance at the posterior end of this net, numerous long, blind, often spirally coiled tubules are given off from the dorsal vessel and also from some of the laterals. Some of these branch near their base (pl. 29, fig. 3).

Color in life: Ground color pale buffy, suffused with pale or warm sepia, some examples decidedly dark at posterior end, collar pale Hays maroon, madder brown, or liver brown (Ridgway's Color Standards and Nomenclature, pls. 13 and 14); main stem of tentacles the same; branchlets and tips pale yellow, sometimes mottled with madder. In alcohol, paler, the sphincter anterior to the zone of the hooks becoming bluish or purplish. Some of the specimens from Baja California are deeper, ruddy brown with rough skin and reddish brown tentacles. The very large specimen from Bodega Head, Calif., was ochraceous-tawny on the trunk becoming paler on the introvert.

Young.—Up to about 18 mm. in length this species has no hooks or spinelets on the introvert. In a considerable series there is a well-expanded example 18 mm. long with four hooks well forward on the introvert, placed symmetrically, two on each side of middorsal line. A wide zone in front of and including anus is spotted with well-spaced, low, brownish glands of conspicuous size; behind this zone the spots are very much smaller and closer together. In front of the anal zone the glands are paler than the skin and transversely elongated. General

color, bleached sepia. Another specimen, about the same length, has the anal zone a warm brown, which is characteristic of most of the young specimens with or without spines. The tentacles, already voluminous, more obviously number four than they do in adults. Each tentacle has two or three branchlets bearing the ultimate tentacules. Another specimen, only slightly longer, has 18 hooks in about 5 spaced groups. A 24-mm. specimen has more than 50 hooks.

In the above lot there are 12 specimens, measuring from 9 to 18 mm., which have no hooks, but have four tentacles and body markings the same as the young with hooks.

Type.—Originally in the Museum of Comparative Zoology but no longer in existence.

Type locality.—Laguna Beach, Orange County, Calif.

Distribution.—From Coos Bay, Oreg., to San Quintín, Baja California.

Specimens examined.—As follows:

Coos Bay (North Bay), Oreg., eelgrass roots, July 26, 1949, D. L. Reish, 2 specimens.

Crescent City, Calif., June 11, 1913, W. F. Thompson, 2 specimens (body cavity full of eggs).

Bodega Head, Calif., in sand under rock, Aug. 4, 1948, D. M. Wootton, 1 specimen.

Tomales Point, Marin County, Calif., 1939, E. F. Ricketts, 5 specimens.

Monterey Bay, Calif. (vicinity of Pacific Grove), intertidal, granitic rocks, numerous specimens.

Santa Rosa Island, Calif., southeast Sandy Point, in rock, January 27, 1949, D. M. Wootton, 1 specimen.

San Clemente Island, Calif., June 20, 1896, H. B. Torrey, 3 specimens.

Ensenada and Boca del Playa, Baja California, E. F. Ricketts, 7 specimens.

San Quintín, Baja California, March 1949, Patrick Wells, 3 small specimens.

Remarks.—In the Monterey Bay region this species spawns during the latter part of February and early March at the same time as *D. dyscritum*.

This is probably the species upon which Sato (1930, p. 27) bases his California record of *D. blandum*, which is a comparatively small animal (upward of 50 mm.). The tentacles (Sato, 1930, fig. 10, p. 24) are much simpler than those of *pyroides*. The four primary trunks divide at once to form eight subequal tentacles. The ultimate tentacules are arranged pinnately along both sides of each of these arms in a single series. Sometimes there is an extra smaller branch between two principal branches. Such tentacles are not dendritic. The fixing muscles have a different arrangement: F^1 is where F^2 is in *pyroides;* F^2 seems to be attached to the intestine or the end of the rectum at about the position of coecum, which is lacking in *blandum*. F^3 is about the same as in *pyroides*.

DENDROSTOMUM HEXADACTYLUM Sato

PLATE 30, FIGURE 2

Dendrostoma hexadactylum SATO, 1930, p. 28, figs. 13–15; pl. 4, figs. 20–24; 1937, p. 162, pl. 4, fig. 17; 1939, p. 412.

Diagnosis.—In general appearance closely resembling *Dendrostomum pyroides;* differing in having six tentacles and larger and more numerous introvert hooks, among which are very numerous and very small upright cylindrical papillae.

Description.—The only available large specimen, at maximum contraction, is 60 mm. long. It was found by E. F. Ricketts on the beach at Monterey, Calif., during a heavy storm (January 7, 8, 1939) and was taken from a fragment of gray shale rock along with boring clams. The hooks are fully twice as numerous as in a *Dendrostomum pyroides* of equal size and are obviously larger. The largest are situated anteriorly, next to the smooth collar, and measure 0.5 to 0.68 mm. in length by 0.3 to 0.4 mm. in diameter at base. The numerous cylindrical papillae, without constricted base, are about 0.1 mm. high and are scattered thickly among the spines. Posterior to the zone of spines they flatten into ellipsoids with convex center, are close together, and often occupy a quadrilateral area defined by five creases in the cuticle. At posterior end of the body certain of them become low papilliform; possibly all are so in life. The major axis of the flattish papillae in Sato's types varied from 0.06 to 0.107 mm.; the minor, from 0.05 to 0.105 mm. In my specimen, which is larger than any of Sato's, the papillae are a little larger.

The tentacles spring from 6 roots, which branch either twice or three times near the base so that the count of tentacular arms is likely to exceed 12. The branching is similar to that of *D. zostericolum.* The internal anatomy resembles that of *D. pyroides*, with the following important exceptions: Fixing muscle 1 is not so far forward (between F^1 and F^2 of *pyroides*); F^2 is nearer the intestinal spiral and usually has 2 terminal branches, one attached to post-esophagus, the other to ascending spiral of intestine well back of the coecum; F^3 is attached to intestine posterior to F^2 branch. The contractile blood vessel lacks the elaborate network of the vessels surrounding the esophagus, although there are a few small collateral loops; but the long Polian tubules are more numerous and, instead of branching off toward the distal end of the main vessel as in *pyroides*, arise all along each side from a point in front of the lateral mesenteries of the esophagus. Some of them branch near the base. The origin of the retractors is straighter than in *pyroides* and the gonad is on the muscles rather than on the body wall.

In front of the anterior end of the nephridia are four short, transverse, parallel muscles, resembling low dissepiments, mentioned by Sato. They occur also in *Dendrostomum pyroides.* The posterior merges with the wing muscles.

The nephridia are relatively longer (40 mm.) than in Sato's figure, reaching nearly to base of the retractors. Only 15 mm. of the left nephridium remains in place; the terminal 25 mm. was floating free. The ruptured end of each part was perfectly healed.

Type locality.—Mutsu Bay, northern Honshu, Japan.

Distribution.—Northeastern Honshu; Monterey Bay, Calif.

Specimens examined.—As follows:

Monterey Bay, Calif., 1 large specimen from shallow water, which evidently lived in a cavity excavated by boring mollusks in gray shale, E. F. Ricketts.
Northeast of Monterey, Calif., 15 to 20 fathoms, G. E. MacGinitie, 1 specimen.
Albatross station 4496, 2.1 miles off Santa Cruz, Calif., 10 fathoms, rocky bottom with fine sand, 4 specimens.

Remarks.—Sato (1937, p. 163) reported specimens from Takada, Iwati Province, measuring upward of 180 mm. long and 18 mm. in diameter. In Japan it is found between tide marks.

DENDROSTOMUM ZOSTERICOLUM Chamberlin

FIGURE 87, A; PLATE 30, FIGURE 1; PLATES 31, 32

Dendrostoma zostericola CHAMBERLIN, 1919, p. 30.—PEEBLES and FOX, 1933, p. 201, figs. 1–11.
Dendrostoma mytheca CHAMBERLIN, 1919, p. 30.

Diagnosis.—Tentacles six, branching profusely, either one or both dorsals usually smaller than the others; body long and slender, usually broadest posteriorly, the posterior end rounded to bluntly pointed; some specimens, especially those fixed in formalin and with introvert retracted, may be just the opposite: broadest anteriorly, slender and elongated posteriorly. Introvert relatively short, with scattered tiny clavate papillae, which decrease in size toward broad, smooth zone behind tentacles; no hooks on introvert; skin rather smooth, the postanal region uniformly peppered with very tiny brown glands, which in anal zone gradually lengthen into the papillae of introvert; nephridia very long, opening close behind anus; dorsal contractile vessel with 10 to 12 very long terminal branches. Related to *Dendrostomum peruvianum* Collin.

Description.—This species is one of the long, cylindrical Dendrostoma, in which the length increases over the breadth as the animal grows to large size. The largest preserved specimen (Point Conception) is 245 mm. to base of tentacles; introvert (anus to base of tentacles) 30 mm.; thickness of trunk, 10 mm. The introvert however is contracted and unnaturally short. The more usual proportion of the introvert to total length is about one-fifth, as in examples around 150 mm. in length. The bare zone at anterior end of the introvert occupies one-fourth to one-third total length of latter, again depending upon the condition of the specimen.

The tentacles usually branch into two main stems near the base, and continue to add branches with age, but the tentacles are often

asymmetrical in size. Numerous specimens have the two dorsals conspicuously smaller than the others, or one small and one large dorsal. With the above condition, any one or two other tentacles may be smaller than normal size. The figure of oral disk (pl. 30, fig. 1) shows the primitive condition of four food grooves leading from mouth, and how the original two dorsal tentacles were converted to four, producing a dorsoventral asymmetry. Just back of the upper flange of upper lip is a conspicuous nuchal organ, which is broader than long, with shallow longitudinal furrows. At its anterior margin is a crescentic slit, between which and the lip flange is a ridge connecting the bases of the two dorsal tentacles.

The skin papillae of the introvert are rather thick clavate, unequal, the largest (0.135 mm. long) being at the base of the introvert, whence they decrease in size toward the anterior smooth zone. Posterior to the anus they very rapidly decrease in size to the dark brown, only slightly convex, specks rather evenly and closely scattered over the rest of the body. These are 0.04 to 0.07 mm. in diameter and, like the papillae, have a central aperture (pl. 31, fig. 4.).

The essential features of internal anatomy are shown in the figures. The muscles have a satiny luster and the inner thin longitudinal layer is transversely crinkled like silk. Between the circular and longitudinal layers are narrow bands of oblique fibers, which are more conspicuous in small than in fully grown specimens. They do not extend in front of the anus, are irregularly spaced, and not bilaterally symmetrical. In a small specimen 11 could be counted on one side of the body. Peebles and Fox (1933), refer to these as "the so-called veins." The fibers are easily demonstrated. The two long retractors do not join until a short distance behind the head. Rarely one of the retractors is split in two. The distance between the posterior end of the retractors and the end of the body varies; in well relaxed specimens it is one-fourth the body length, or a little more. But in the big specimen from Point Conception the distance is a little over one-third the body length.

Characteristic are fixing muscles F^1, F^2, F^3. F^1 is attached to ventral surface of esophagus, posterior to end of contractile vessel, and passes backward to dorsal body wall. F^2 leaves the postesophageal gut at the top of the spiral, while F^3 anchors the ascending intestine posterior to the coecum. But either F^2 or F^3 is sometimes absent—

FIGURE 87.—Demonstrating attachment of fixing muscles, or intestinal anchors, in three species of *Dendrostomum:* A, *Dendrostomum zostericolum.* B–E, *D .dyscritum:* B, Specimen from Crescent City, Calif.; C, specimen from Crescent City that lacks F^1 and has abnormal attachment F^2 (right nephridium is anchored to spindle muscle); D, specimen from Pillar Point, San Mateo County, Calif. (F^1 is displaced; F^2 has two strands); E, specimen from Monterey Bay (one strand of F^2 sends two branches to postesophagus. F, *D. schmitti*, paratype from Independencia Bay, Peru (F^2 is divided equally between postesophagus and ascending gut.

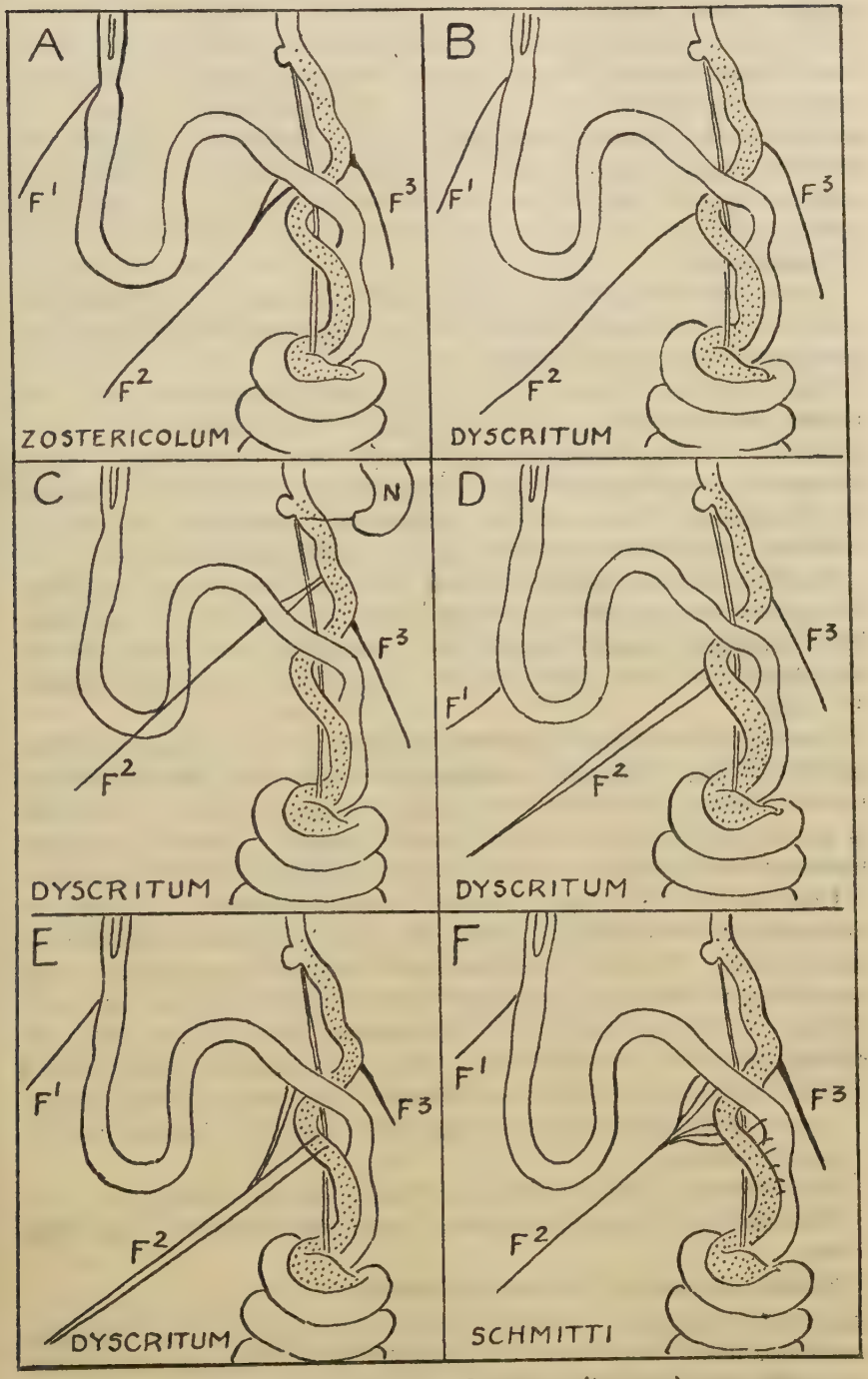


FIGURE 87.—(For legend see opposite page.)

in the largest specimen both F^2 and F^3. Apparently F^2 never anchors the ascending intestine as in *dyscritum* (fig. 87, A, B). There are between 20 and 30 coils in the intestinal spire. Between the point of insertion of F^1 and F^2 on the postesophageal gut very tiny pointed protuberances, resembling conical papillae, may be seen in a small minority of specimens. These are probably rudiments of the more prominent and longiserially arranged structures which Collin (1892, p. 180, pl. 11, fig. 13) cites as being especially characteristic of *D. peruvianum*.

The nephridia are slender, free, and very long in all specimens dissected. In natural position the nephrostome opens forward and toward the dorsal median line.

The contractile vessel (pl. 31, fig. 2) gives off on each side a collateral small vessel, which forms a series of loops along the side of the main vessel and continues posteriorly on the esophagus. These vessels do not ordinarily form a vascular net on the ventral side of the esophagus. Terminally the contractile vessel gives off 10 to 13 very long slender blind tubules, one of which is median.

In all specimens examined, most of which were taken in winter, the gonads are slender transverse bands at the base of retractors. The secondary gonads described by Peebles and Fox (1933, p. 205, figs. 5, 6) have not been observed. Eggs in coelom observed August 10, 1948.

The brain is situated slightly forward of the nuchal organ, therefore under the ridge of tissue connecting the bases of the two dorsal tentacles. The anterior border is deeply notched and a tiny eye spot is present on each side near the anterior margin. When the introvert is retracted the brain is beneath a tough sheath of the united retractors.

Color in life: "The ground color is deep buff marked by dark gray grooves and lines, most of which are due to wrinkles produced in contraction. The collar is smooth and whitish in appearance. The conspicuous arborescent tentacles vary in color from pale yellow to brown, red, or dark purple." (Peebles and Fox, 1933, p. 202.) In alcohol the color is pale brown, dark on contracted area, with a definite brown zone at anus; in formalin it is usually reddish brown.

Type.—Formerly in the Museum of Comparative Zoology but no longer in existence.

Type locality.—Laguna Beach, Orange County, Calif.

Distribution.—Point Conception, Calif., to Ensenada, Baja California.

Specimens examined.—From California:

Near Point Conception, intertidal, July 14, 1916, C. L. Hubbs, 2 specimens.
Santa Rosa Island (Beechers Bay and mouth of Gavanon Canyon), Aug. 10, 1948 (eggs), D. M. Wootton, 2 specimens.
Santa Barbara, tidal sand at Hendys Beach, Patrick H. Wells, 8 specimens.

San Clemente Island, June 20, 1896, H. B. Torrey, 3 specimens.
Newport Bay, in sand under rocks, January–February 1930, G. E. MacGinitie, 9 specimens.
Newport Bay, Corona del Mar, open rocky shore under rocks, Jan. 5, 1936, 1 specimen.
Anaheim Slough, Oct. 12, 1932, G. E. MacGinitie, 4 specimens.
La Jolla (Bird Rock), Earl H. Myers, 4 specimens.
San Diego, E. C. Starks, 2 specimens.

From Baja California:

Ensenada, among eelgrass roots; in gravel and sand under boulders; rocky tide flats, in sandy mud at lowest part of intertidal zone; midwinter, G. E. MacGinitie and E. F. Ricketts, 117 specimens.

Remarks.—The species is probably the North American equivalent of *Dendrostomum peruvianum* Collin (1892, p. 179, pl. 11, figs 7 and 13), Callao, Peru. The two types were only 25 and 30 mm. long; tentacles four, and esophagus posterior to the end of the contractile vessel carries relatively conspicuous slender protuberances arranged in longiseries. The nephridia are short. Fixing muscles F^1, F^2 and F^3 are essentially as in *zostericolum*, but there is an F^4 attached to the gut spiral back of F^3. The dermal glands are similar to those of *D. zostericolum* in being low papilliform on the introvert. Further study of *peruvianum* will possibly change the tentacle count from four to six. In my small *zostericolum* the two smaller dorsals can be considered branches of the adjacent larger tentacles, which would give a count of four primaries. *D. zostericolum* does not possess at any age an F^4 fixing muscle or *prominent* protuberances on the postesophagus. The nephridia in extended young specimens are long, reaching to the origin of the long retractors.

Dendrostoma mytheca was based on a 20-mm. specimen from Laguna Beach that is no longer in existence. The trunk measured 12 mm., introvert 8 mm. The body was widest at the posterior end. The principal characteristic is a "band of abruptly much larger tubercles about the base of the introvert, distad of which region they become again abruptly smaller"; the number of tentacles was not given. This may well have been a young *Dendrostomum zostericolum*, most of which have the enlarged glands, or even an immature *pyroides* (without hooks), which has a zone of larger brown glands at the anus.

DENDROSTOMUM PERIMECES Fisher

PLATE 27, FIGURE 3; PLATE 28, FIGURE 1; PLATE 30, FIGURE 4; PLATE 33

Dendrostoma perimeces FISHER, 1928, p. 196, pl. 6, figs. 3, 3*a*; pl. 7, fig. 1; pl. 8, figs. 2, 2*a*.

Diagnosis.—Very long and slender; tentacles six, bushy; no hooks on introvert. Similar in general habit to *Dendrostomum zostericolum*, but even longer; differing in having more numerous introvert papillae, which do not thin out forward and do not diminish so conspicuously in size; body glands convex, of two or three sizes; collar not obviously reddish or purplish; fewer (6 to 9) Polian tubules at end of contractile

vessel; nephridia shorter; alimentary canal much longer, the spire consisting of upward of 100 coils.

Description—This is a larger species, adult specimens from the type locality being 150 to 260 mm. long, while one from Tomales Bay measures 320 mm. and must have been considerably longer when living. The body is very slender, cylindrical, tapering very gradually to the rounded or bluntly pointed posterior end. The greatest width of fully extended living specimens is one-twelfth to one-twenty-fifth the total length—usually nearer one-twentieth. The introvert is cylindrical, its length about one-sixth to one-seventh the total length; the anterior fifth of the introvert is a glossy brown collar or zone, marked by fine creases. This collar is followed by a smooth, not so broad whitish zone. Back of this the skin is pale sepia thickly peppered with tiny dark-brown papillae, which are more numerous than in *Dendrostomum zostericolum*, especially anteriorly (pl. 27, fig. 3, *a*). Posterior to the anus these are replaced by strongly convex brown glands or low protuberances, generally of three sizes, from 0.04 to 0.1 mm. diameter. When the skin is stretched, very small, inconspicuous subquadrate areas can be discerned, with one of these glands to an area. The tentacles are similar to those of *zostericolum*, bushy in large specimens, and one or both of the dorsal tentacles are smaller than the others. In the very large Tomales Bay animal, with well-expanded tentacles, both dorsals are conspicuously smaller than the others. The nuchal organ is broader than long, the surface is furrowed and the anterior margin is hidden by a broad crescentic slit.

The longitudinal muscle layer is satiny smooth and the oblique bands of muscle between it and the circular layer are more conspicuous than in large examples of *D. zostericolum*. The two large retractors are impressively long and have their origin at the beginning of the posterior fifth of the body. The line of attachment is either concave or straight. The spindle muscle is attached as in *zostericolum*, but is longer in accordance with the greatly lengthened intestine. Fixing muscle F^1 seems not to be always present and F^2 and F^3 are absent.

Perhaps the most conspicuous difference between the two species is the much longer intestine of *D. perimeces*. In a specimen that is by no means the largest, there are about 100 single coils in the spiral, while in *D. zostericolum* there are less than half as many.

The contractile vessel terminally has six to nine blind tubules. Branches from the collateral vessels pass along the ventral side of the esophagus and sometimes anastomose, but do not form a network.

The nephridia are similar to those of *D. zostericolum* but allowing for variation are definitely shorter than in that species. The nephrostome opens directly forward.

The brain is similar to that of *zostericolum* but of a slightly different form, the anteroposterior dimension being greater. The eye spots are very tiny.

Color in life, light dull sepia (pale grayish brown), darkest on introvert; anterior collar of introvert brown, sometimes slightly ruddy; tentacles pale olive green or brown, sometimes whitish on sides opposite grooves.

Type.—U.S.N.M. No. 19615.

Type locality.—Elkhorn Slough, a tributary of Monterey Bay, Calif. In sandy mud, among *Zostera.*

Distribution.—Known only from California, intertidal and shallow water, Bodega Head to Venice. Probably south of Monterey Bay the species is found only off shore.

Specimens examined.—From California:

Elkhorn Slough, Monterey Bay, G. E. MacGinitie, 12 specimens.
Tomales Bay, tide flats about 1 mile south of mouth, secured while collector was digging for gaper clam, *Schizothaerus nuttalli*, Aug. 26, 1941, S. F. Light, 1 specimen.
Bodega Head, sand, D. M. Wootton, 1 specimen.
Off Venice, shallow water, sandy mud, M. W. de Laubenfels, 3 specimens.

Young specimen.—Length 49 mm. None of the fixing muscles are present; nephridia 9 mm.; contractile vessel with 6 Polian tubules; intestinal spiral with 60 coils; oblique muscle bands very inconspicuous. In small *zostericolum* the fixing muscles are strongly developed, the nephridia are one-half to three-fourths the length of the fully extended specimen, the contractile vessel has 10 tubules, and the oblique muscle bands are more conspicuous than in adult.

Specimens from off Venice, Calif.—Dr. M. W. de Laubenfels collected 3 specimens that were washed up on the beach during a storm. These had been roughly used by waves and unnaturally lengthened. They measure 480, 620, and 660 mm. long, the posterior part being very attenuate. Even so the nerve cord of the shortest was not broken. The retractors of this specimen are 320 mm. long. From the introvert papillae and the few (9 or 10) Polian tubules at end of the contractile vessel, I have identified these specimens as *perimeces.* In the smallest, least mutilated specimen the tenacular crown is voluminous. The introvert at the collar is 10 mm. thick, which is about twice that of the type, and the same dimension as in the large Tomales Bay specimen. It is safe to estimate this specimen as having a length of about 350 mm. when naturally relaxed.

DENDROSTOMUM DYSCRITUM, new species

FIGURE 87, B–E; PLATE 30, FIGURE 3; PLATE 34

Diagnosis.—Differing from *Dendrostomum zostericolum* in having a shorter, thicker body, about three times length of introvert, fusiform

to subpyriform; retractor muscles attached to body wall a little less to a little more than five-sixths total length from mouth; fixing muscle F^2 attached to ascending intestine behind F^3 with sometimes a subsidiary branch to postesophagus; Polian tubules more numerous. Tentacles six, the two dorsals shorter than the others. Length upward of 170 mm.

Description.—It is difficult to state any external characters by which specimens of *dyscritum* may be distinguished easily from *zostericolum*, other than the shorter trunk. The body is peppered with small, rather uniform, circular, convex, light-brown or dark-brown glands, 0.08 to 0.1 mm. in diameter, and situated about 0.5 mm. apart on body and 0.25 mm. on introvert. They are thus larger than in *zostericolum* and the border of each gland is more sharply defined. On the introvert they lengthen to low papilliform and extend to the red collar, which is smooth. In a zone around the anus the glands are usually larger and more widely spaced than on the body, and the roughly rectangular areas of the cuticle are more obvious. The same thing occurs in many specimens of *zostericolum*, especially when they are small.

The distance between the origin of the retractors and the posterior extremity is much shorter than in *D. zostericolum*, being from one-fifth to a little less than one-sixth the total length. In *zostericolum* the distance is one-fourth to one-third the total body length. The spindle muscle is strong, attached dorsal to anus and is fused to the wall of the rectum as far as coecum, beyond which it anchors ascending spiral of intestine, by muscular strands in the generic manner. The attachment of the fixing muscles F^1 and F^3 is normally as in *zostericolum;* F^2 is not attached to the postesophageal gut but to the intestine at the top of the spiral, normally behind F^3 (fig. 87, B). In one variation (Crescent City) F^2 is attached to the postesophageal intestine and from its opposite side continued to the ascending gut (fig. 87, C). Other variations are shown in fig. 87, D and E. F^1 is occasionally absent (fig. 87, C), or it moves backward on the gut (fig. 87, D), while F^2 may be double (fig. 87, D, E). Rarely, F^1 and F^2 are absent (specimen 170 mm. long, Crescent City).

The alimentary canal shows no outstanding peculiarity. The spiral contains 15 or 16 double coils (30 to 32 single). The nephridia are shorter than in *zostericolum*. They vary from the maximum as shown in plate 34, figure 1, to about one-half that length.

The contractile vessel has more numerous Polian tubules than in *zostericolum*, they branch at the base as well as distally, and they are more crowded at the distal end of the contractile vessel than in *zostericolum*. Plate 30, figure 3, shows a typical example.

Color in life: Body dark olive-green, greenish yellow, or sepia, sometimes stained blackish by the mud in which they live; introvert

lighter, sometimes yellowish or grayish anteriorly; collar back of tentacles dull reddish purple; tentacles brown, becoming pale and translucent on the hundreds of ultimate tentacules, which at their base are bright pale yellow. Formalin specimens are reddish gray or brown; those preserved in alcohol are bleached sepia or sometimes orange-brown.

Young.—A specimen 26 mm. long, fully extended, from near the type locality, has the form of the adult. It so much resembles the smaller spineless young of *Dendrostomum pyroides* that a dissection was made to determine the differences. F^2 is attached to the ascending gut as in fig. 87, B. The tentacles are less voluminous than in the 18-mm. young *pyroides*. There are basically four tentacles, the extra two of the adult arising from the growth of the inner branch of the two dorsal tentacles. Young *dyscritum* lacks, in front of the spotted anal zone, the area of transversely elongated glands of *pyroides*. The nuchal organ in life was conspicuous light cadmium yellow, and the tentacles light cadmium at base; general tone of skin, pale sepia with a darker zone in anal region.

Type.—U.S.N.M. No. 21221, N. W. Riser, 16 specimens, spawning at end of February and early March 1948.

Type locality.—Monterey Bay, Calif., intertidal, in sand between ledges of granite at Hopkins Marine Station, Pacific Grove.

Distribution.—Point Conception to Crescent City, Calif., intertidal to 10 fathoms.

Specimens examined.—All from California:

Crescent City, intertidal, June 3, 1911, W. F. Thompson, 32 specimens.
Dillon Beach, near Tomales Bay, Marin County, intertidal, in fissure of rocks with *Pholadidea* and *Petricola carditoides*, June 2, 1941, D. F. Hoffmeister, 1 specimen.
Dillon Beach, North Rocks, Dec. 11, 1947, R. J. Waidzonas, 3 specimens.
Pillar Point, Half Moon Bay, intertidal, March 12, 1911, W. F. Thompson, 6 specimens.
Monterey Bay, intertidal, the type series; *Albatross* station 4496, off Santa Cruz, 10 fathoms, fine gray sand and rocks, May 19, 1904, 6 specimens.
Point Conception, intertidal, July 14, 1916, Carl L. Hubbs, 1 specimen.

Remarks.—A specimen collected February 24, 1948, by Dr. N. W. Riser, was observed discharging sperm from one nephridiopore. Later, when I dissected this specimen, I found eggs in the body cavity. Dr. Riser collected a specimen on March 20 that contained sperm in one nephridium and eggs in the other. The gonad was invisible.

DENDROSTOMUM LISSUM, new species

PLATE 35

Diagnosis.—A small, thick-set species, with short body; introvert short, thick, devoid of spines and papillae; glands of skin minute,

convex, closely placed; tentacles relatively large, profusely branched, in fours; nephridia opening a conspicuous distance posterior to anus; gut-fixing muscle F^2 attached to ascending intestine; gonad on retractor muscles anterior to their base; Polian tubules branched, numerous. Length of trunk to anus 24 mm.; length to base of tentacles 30 mm.; tentacles 4 mm.; breadth of introvert 3.5 to 4 mm.

Description.—Size small; the body short, the trunk thick set; the thick cylindrical introvert about one-fourth the body length, its anterior third a perfectly smooth, translucent collar, while the rest of the introvert, which is whitish, is crowded with minute convex glands. The body is warm sepia with a darker zone including anus and nephridiopores and one at the posterior extremity. It is very closely covered with low-convex glands, 0.08 to 0.1 mm. in diameter, similar in form to those of introvert, and more or less in transverse serial alinement. They are rather nondescript under high magnification by transmitted light (pl. 35, fig. 3). By reflected light the central canal shows as a dark spot. In the darker anal zone the cuticle is thicker and the glands are deeper, crowded, transverse elliptical (0.02 mm. by 0.07 mm.). In a narrower zone between the anus and nephridiopores there are larger, more superficial, transversely elliptical glands which show as inconspicuous brown spots of about two sizes.

The tentacles branch profusely. One can count four or eight, depending upon the value assigned to each arm. The oral disk has four principal food grooves, each of which divides into two, and each of these goes to an arm. If a sagittal plane and one at right angles is drawn (see arrows, pl. 35, fig. 4), each quadrant contains one of the four primary food grooves, and one tentacle with two arms, or two tentacles, depending upon the point of view. But the two arms in the upper right quadrant branch a little sooner than the others, which gives them more the appearance of primary tentacles than is the case with the two upper left. Hence one might easily reckon the number as five, if reference were not made to the food grooves. The tentacles are light brown. The nuchal organ has a lengthwise V-shaped depression.

The retractors are large and attached at the beginning of the terminal fifth of body. The line of attachment is straight and very broad, and the inner ends nearly meet under the nerve cord, which here gives off numerous nerves to the muscles. The muscles are separated practically to the nuchal organ. The spindle muscle follows the usual course from its attachment above the rectum. The wing muscles are very broad, the left somewhat broader than the right. Fixing muscles F^1, F^2, and F^3 are attached about the same as in *Dendrostomum dyscritum*, F^2 being attached to the uppermost coil of the ascending intestine while F^3 is attached opposite the coecum. The longitudinal, inner muscle layer has a satiny luster and is crinkled transversely. No oblique strands are observable.

Nephridia unequal, the longer about one-third the body length. They differ from all the California species in opening a conspicuous distance behind the anus.

The intestinal spiral has 26 coils. Postesophageal gut rather short. A constriction just posterior to attachment of F^1 marks the end of the esophagus proper.

The vascular system is similar to that of *D. dyscritum*. Even though the specimen is small there are very nearly as many Polian tubules as in a large *dyscritum*, and a majority branch near the base.

Type.—U.S.N.M. No. 21222, March 3, 1940, E. F. Ricketts, 1 specimen.

Type locality.—Point Lobos, Espíritu Santo Island, near La Paz, Baja California.

Distribution.—Known only from intertidal zone, Gulf of California.

Specimens examined.—From Mexico:

San Carlos Bay, on the Gulf side of Baja California, March 30, 1940, E. F. Ricketts, 1 specimen.

Puerto Penasco, Baja California, Dec. 24, 1947, W. H. MacGinitie, 13 retracted specimens from 6 to 16 mm. long. The smallest have a translucent body wall.

Miramar Beach, Guaymas, rocky, shore, Feb. 10, 1948, W. H. MacGinitie, 3 specimens about same size as type.

Remarks.—Whether the representatives of this species are always small it remains for future exploration to ascertain. The nearest relative is a large species, numerous examples of which were collected by Dr. Waldo L. Schmitt at Independencia Bay, Peru. With one exception all the specimens are strongly contracted, but the length of the largest would probably be between 100 and 150 mm.; thickness 15 to 20 mm. The skin is smooth and grayish and there are no elevated papillae or spines on the introvert. The crowded glands of the body are transversely elongated and do not form conical elevations, although on the introvert they do to some extent. The nephridia open well behind the anus as in *lissum*. In the one specimen having partly extended tentacles there are four major stems, each divided into two principal arms near the base, and the two dorsal tentacles are much smaller than the ventrals. All branch profusely.

Fixing muscle F^2 anchors both the postesophageal gut and the uppermost coil of the ascending intestine by sending branches to each (fig. 87, F). F^1 is attached to the esophagus in the usual place, and F^3, a short distance posterior to the coecum. The retractors are powerful and arise considerably farther forward than in *lissum*, as is to be expected in the much larger animals. The gonads are not situated on the muscles, but the stolon lies on the body wall behind the line of origin of the retractors, which is concave to nearly straight. In a large specimen the gut spiral has 27 double coils. The nephridia would be regarded as long, since they extend posterior to the origin of

the retractors and sometimes to the end of the body. Allowing for the much greater size of the specimens, the Polian tubules are not quite so well developed as in *lissum*. The brittle condition of the material makes it difficult to work out details, but the plan is very similar to that of *D. dyscritum*. This species appears to be new and may be named:

DENDROSTOMUM SCHMITTI, new species

FIGURE 87, F

Dendrostomum schmitti differs from *D. peruvianum* Collin in lacking introvert papillae, convex trunk papillae, and elevations on esophagus. The nephridia open posterior to the anus, and F^2 anchors both the descending and the ascending gut, not the postesophageal gut alone. The relationship of *schmitti* to *peruvianum* parallels that of *D. lissum* to *D. zostericolum*.

Between *lissum* and *schmitti* the relationship is close; possibly they represent the extremes of geographic variation of one species.

Type.—U.S.N.M. No. 21216.

Type locality.—Independencia Bay, Peru, lee side of Vieja Island.

Genus PHASCOLOSOMA F. S. Leuckart

Phascolosoma F. S. LEUCKART, 1828, p. 22, fig. 5. (Type, *Ph. granulatum* Leuckart.) —FISHER, 1950a, p. 551.
Phascolosomum DIESING, 1851, p. 63, partim; 1859, p. 758, partim.
Phascolosoma KEFERSTEIN, 1862, p. 39, partim; 1865b, p. 422, partim.
Phymosomum QUATREFAGES, 1866, vol. 2, p. 621.
Phymosoma SELENKA and DE MAN, 1883, p. 54 (emendation of *Phymosomum*). Preoccupied by *Phymosoma* Archiac and Haime, 1850, Description des animaux fossiles du groupe nummulatique de l'Inde . . . , p. 54.
Physcosoma SELENKA, 1897, p. 460.—SPENGEL, 1898, p. 50.
Prophymosoma LAMBERT, 1900, p. 54.
Physconosoma BATHER, 1900, Zoological record, Echinoderms, p. 78.

Diagnosis.—Tentacles in a single series, forming a crescent or a circle (open dorsally), which is situated *dorsal to the mouth* and encloses nuchal organ; longitudinal muscle layer of trunk usually split into separate but more or less anastomosing fascicles; usually four retractors, the dorsal and ventral of each side tending to fuse in some species; body covered with papillae fortified by tiny chitinous platelets; introvert hooks, arranged in rings, usually present (not in *Phascolosoma antillarum*); a dorsal contractile vessel, in most species without villi (present in *Ph. antillarum*).

Remarks.—In this genus the arrangement of tentacles is farthest removed from the ancestral type, in which they form a circle surrounding the mouth, with the brain and nuchal organ (if present) outside the circle. In *Phascolosoma* the brain and nuchal organ are situated within the tenacular crown and the mouth is outside and

ventral to the circle. The oral disk, including the tentacles, is surrounded by a cephalic collar, while a short distance posterior to this is a thin flange of tissue forming a second, or cervical, collar.

It is unfortunate that the name *Physcosoma* long used for this genus is untenable, since it is preoccupied by *Phascolosoma*. This name dates from F. S. Leuckart, 1828, page 22. The type and only species mentioned by Leuckart is *Phascolosoma granulatum* Leuckart, type locality Cette, France. This is the species called *Physcosoma granulatum*. In Selenka's monograph (1883, p. 79) it appears as *Phymosoma granulatum*, the first citation of the synonymy reading: "*Phascolosoma granulatum* F. S. Leuckardt, Breves animal. descript. Heidelberg, 1828. 4. p. 22, Fig. 5." The confusion started with Quatrefages (1866), who divided *Sipunculus* into five subgenera: *Sipunculus*, *Phascolosomum* Diesing, *Phymosomum*, *Aedematosomum*, *Cryptosomum*. Diesing's (1851) *Phascolosomum*, an emended spelling of Leuckart's name, included species of *Physcosoma*, *Phascolosoma*, and *Phascolion* as used by Selenka and subsequent authors and was thus an expansion of Leuckart's genus. This enlarged *Phascolosoma* was employed by Keferstein, 1862, 1865, 1866, 1867, Baird, 1868, Grube 1859, and others. Obviously Quatrefages's blunder consisted in placing the type (*Phascolosoma granulatum*) in his subgenus *Phymosomum* instead of where it belonged. Quatrefages used *Phascolosomum* for the group which includes *Phascolosoma vulgare*. Apparently no one was satisfied with original spellings; Selenka and de Man (1883) changed *Phymosomum* to *Phymosoma* and adopted Quatrefages' genus, with additional new species. *Phascolosomum* (Diesing) Quatrefages became *Phascolosoma* F. S. Leuckart (Selenka and de Man) with a new type, *Phascolosoma vulgare*, and more new species. *Phymosoma*, being preoccupied, was changed by Selenka (1897) to *Physcosoma* and adopted by authors. *Phymosomum* Quatrefages, *Phymosoma* Selenka and de Man, *Physcosoma* Selenka, *Prophymosoma* Lambert, and *Physconosoma* Bather are synomyms of *Phascolosoma* Leuckart.

KEY TO SPECIES OF PHASCOLOSOMA HEREIN DESCRIBED

a[1]. Rings of tiny hooks present on anterior part of introvert; tentacles short, digitiform, 24 or less; introvert more than half length of trunk.

b[1]. Introvert with numerous prominent dorsal, conical, sharp papillae or tubercles, sometimes directed posteriorly.

dentigerum (Selenka and de Man) (p. 432)

b[2]. Papillae on dorsum of introvert not conspicuously enlarged.

c[1]. Clear streak of hooks with conspicuous expansion, and merged below with the triangular clear space; platelets of papillae beyond the crowded central zone, fewer and spaced---**puntarenae** Grube (p. 430)

c[2]. Clear streak of hooks with an inconspicuous expanded portion, or none, and not merged with triangular clear space; platelets of papillae more numerous and more crowded in outer zone.

agassizii Keferstein (p. 424)

a^2. No hooks; tentacles long, filiform, very numerous (50 to 200); introvert half length of trunk or less, robust; trunk dark brown from very numerous papillae ..... **antillarum** Grube and Oersted (p. 434)

PHASCOLOSOMA AGASSIZII Keferstein

PLATE 36, FIGURES 3–6; PLATE 37, FIGURES 4–15; PLATE 38; PLATE 39, FIGURE 1

Phascolosoma Agassizii KEFERSTEIN, 1866, p. 218; 1867, p. 46, pl. 6, figs. 3, 4, 7.
Phascolosoma lordi BAIRD, 1868, p. 92 (Vancouver Island, B. C.)
Phymosoma Agassizii SELENKA, 1883, p. 78.
Physcosoma agassizii CHAMBERLIN, 1919, p. 30; 1920, p. 5d.
Physcosoma japonicum CHAMBERLIN, 1920, p. 5d.

Description.—Size of preserved specimens, with introvert extended, upward of 140 mm. but commonly half that; trunk cylindrical; posterior extremity bluntly pointed. When fully extended the distance from anus to tentacles is three-fourths that from anus to posterior extremity. The body wall varies from slightly translucent to opaque and the skin color from pinkish gray or yellowish gray or pale sepia to reddish brown and dark neutral brown. The lighter colored animals often have a few spots on body (dark purplish brown, neutral brown, reddish brown), which are either obscured or are not present on the darker forms, while the introvert, which is light in shade even when the trunk is dark, is marked by irregular transverse bands and patches of the same variations as the spots, usually along its entire length but sometimes only on the distal part. The skin is rough to the touch from very numerous convex or conical skin papillae of a darker brown than the skin but with a light center. They are smallest midventrally, increasing in size dorsally; and are largest dorsally at posterior extremity and over an area just in front of the anus. Here the papillae are very dark brown, horny, acorn shaped or conical, or in some cases compressed and expanded at base (pl. 38, fig. 31). In front of the preanal area the papillae rapidly decrease in size on the introvert. The relative size of the platelets of the skin-gland papillae is rather constant in specimens of different sizes and from different parts of the geographic range. An example from posterior to anus of a medium-sized example is shown somewhat flattened (pl. 36, fig. 3).

There are 15 to 25 rings of hooks starting a short distance behind the collar, those of the first three to five rows being very small and colorless. Usually there are about 17 rings clearly visible; the last one or two may be incomplete. Twenty-five figures of hooks on plates 20 and 21 give a fair idea of the variation in the proportion of height to base, size of basal piece, the form and position of clear streak, and the triangular spot. All are drawn to the same scale. The expansion in the clear streak may disappear entirely, even in specimens which have it in some of the hooks (pls. 36, 37). The so-called tooth

on the concave margin is frequently absent, while there is no uniformity in the degree of curvature or in proportion of height to base.

Plate 36, figure 4, shows the crown of 24 tentacles and nuchal organ, which is relatively large in this species.

Longitudinal muscle bands anastomose rather freely, but there is great irregularity in the extent in different specimens. The number of bands between the origins of the anterior and posterior retractor muscles varies from 20 to 25, but at the level of the nephridiopores is 15 to 17. In a form from Monterey Bay one or two very narrow strands regularly split off from the principal bands (which are therefore narrower than usual) and remain separate for considerable distances, and are as much independent bundles as the principals. In such a specimen the muscle count runs to 35 or even more. A short distance in front of the anus the longitudinal muscles unite to form a continuous sheet. The introvert is ordinarily not invaginated beyond this point, but can be retracted as far as the anus. In fully expanded specimens the retractors are slender. The ventrals arise at the beginning of the posterior third of the trunk from six or seven muscle bands (first or second to sixth or seventh) but details of the relation differ on the two sides and from specimen to specimen. The dorsals arise from usually the fourth to sixth or seventh (or their equivalents if there happens to be much anastomosis). Plate 39, figure 1, shows the joining of the two retractors of each side to form one and the ultimate fusion of these behind the head. There is a single fixing muscle which shows little variation. It arises from two slender roots on midventral line, in front of origins of the dorsal retractors, and is attached by two distal branches to rectum and postesophageal gut (pl. 39, fig. 1). The roots are attached to muscle bands 1–1 to left of nerve cord. The spindle muscle begins just in front of the anus and is attached at the posterior extremity. The contractile vessel is inconspicuous.

The nephridia are moderately long and attached for nearly their length by a delicate mesentery. The small nephrostome is over the interval between muscle bands 2 and 3.

The nerve cord is loosely attached by its numerous nerves. There are two eye spots on the brain.

The gonad is in the usual place at the origin of the ventral retractors. Ripe eggs are found in the coelom in February and March (Monterey Bay). They are spherical and measure 0.12 mm. in diameter with some as small as 0.1 mm. and others reaching 0.14 mm. In much larger Humboldt Bay specimens coelomic eggs (January 1) have the same dimensions.

Type.—In the Museum of Comparative Zoology.

Type locality.—Mendocino, Calif.

Distribution.—From Kodiak Island, Alaska, to San Quintín, Baja California. There are records from temperate and tropical waters of both hemispheres (see under *Remarks*).

Habitat.—This, the dominant sipunculid of the intertidal zone, has adapted itself to a variety of habitats from midtide horizon to 110 fathoms. It is probably most abundant on the lower half of the intertidal zone and just below low tide. Beds of mussels (*Mytilus californianus*) so characteristic of the California coast afford ideal conditions. It is found also under rocks lying on or in fine sandy to muddy bottoms of tide pools, and in some conditions in crevices of rocks, preferred by *Dendrostomum pyroides*. The root masses of surfgrass (*Phyllospadix*) if not clogged with drifting sand, and holdfasts of kelps afford protection for small specimens. Mr. Ricketts found them also in the fenestrated base of a colony of the hydrocoral *Allopora californica*. Professor MacGinitie found them common in the mud of Humboldt Bay, which evidently afforded favorable conditions, as the specimens are all of large size.

At Orcas Island, Wash., Dr. Richard Snyder found a medium-sized specimen in association with the annelid *Aphrodite*. The sipunculid was in the space between the elytra and the dorsal mat of interwoven chaetal threads and must have entered when very tiny.

Specimens examined.—From Baja California:

Boca de la Playa, near Ensenada, Jan. 21, 1932, E. F. Ricketts, 5 specimens.
San Quintín, April 1949, Patrick W. Wells, 5 specimens.

From California:

La Jolla, 1899, F. H. Robinson, 1 specimen.
San Clemente Island, June 26, 1896, H. B. Torrey, 2 specimens.
San Pedro Point, Sept. 1, 1895, 1 specimen.
Point Firmin, U. S. National Museum collection, 1 specimen.
Santa Monica, March 1889, J. J. Rivers, 4 specimens.
Santa Barbara, under wharf, summer of 1948, Patrick H. Wells, 5 specimens.
Santa Rosa Island (Beechers Bay), mussel bed, Aug. 10, 1948, D. M. Wootton, 34 specimens.
Santa Cruz Island (Frys Harbor), mussel beds, Aug. 12, 1948, D. M. Wootton, 10 specimens.
Point Conception, July 14, 1916, C. L. Hubbs, 2 specimens.
Albatross station 4496, 2.1 miles southeast of Santa Cruz, 10 fathoms, fine gray sand, rocks, May 19, 1904, *Albatross*, 33 specimens.
Albatross station 4551, 4.5 miles northwest of Point Pinos, 56–46 fathoms, rocks, coarse sand, June 7, 1904, *Albatross*, 7 specimens.
Monterey Bay, channel off Moss Landing, 110 fathoms, Nov. 28, 1927, 1 specimen.
Monterey Bay, about 50 feet, from colony of *Allopora californica*, Feb. 10, 1927, E. F. Ricketts, 18 specimens.
Monterey Bay, intertidal, from Point Pinos to Carmel Bay, granite shore, many specimens.
Pillar Point, San Mateo County, March 12, 1911, W. F. Thompson, 10 specimens.
Tomales Bay, Nov. 23, 1947, P. J. Menzies, 1 specimen.

Bodega Head, under mussels, Aug. 4, 1948, D. M. Wootton, 15 specimens.
Black Point, Sonoma County, June 21, 1898, H. P. Johnson, 4 specimens.
Mendocino, paratypes, A. Agassiz, 4 specimens.
Humboldt Bay, low tide, mud, Jan. 1, 1931, G. E. MacGinitie, 200 specimens.
Crescent City, intertidal, June 13, 1911, W. F. Thompson, 14 specimens.

From Oregon:

Coos Bay (North Bay), eelgrass roots, July 20, 1949, D. L. Reish.

From Washington:

Puget Sound, 1896, Trevor Kincaid, 2 specimens.
Dogfish Bay, Puget Sound, Trevor Kincaid, 1 specimen.
Off Browns Island, San Juan Islands, July 18, 1936 (dredged), 2 specimens.
Friday Harbor, San Juan Island, 25 to 60 fathoms, Ida S. Oldroyd, 4 specimens.
Waddah Reef, San Juan Islands, eelgrass hold-fasts, July 4, 1936, 3 specimens.
Deer Harbor, Orcas Island, Aug. 14, 1951 (dredged); found in dorsal elytral space of *Aphrodite*, Richard Snyder, 1 specimen.
San Juan Strait, near mouth of Pysht River, under boulders on muddy gravel, July 26, 1930, E. F. Ricketts, 10 specimens.

From British Columbia:

Clayoquot Sound, Vancouver Island, 1946, E. F. Ricketts, 8 specimens.
Ucluclet, Vancouver Island, in the Museum of Comparative Zoology, 1 specimen.
Round Island, Vancouver Island, June 25, 1945, E. F. Ricketts, 1 specimen.
Canoe Pass, Kate Island, June 21, 1932, E. F. Ricketts, 1 specimen.
Fishermans Cove, July 12, 1932, E. F. Ricketts, 3 specimens.
Calvert Island, under rocks, May 11, 1937, T. T. and E. B. McCabe, 3 specimens.
Huston Inlet, Queen Charlotte Sound, July 1, 1913, W. F. Thompson, 7 specimens.
Table Island, Queen Charlotte Islands, June 9, 1937, 3 specimens.

From Alaska:

Sitka, Crab Bay, rocky reef, E. F. Ricketts, 1 specimen.
Thumb Bay, Prince William Sound, Walter J. Eyerdam, 4 specimens.
Orca, Prince William Sound, June 2, 1899, Harriman Alaska Expedition (W. E. Ritter), 3 specimens.
Cape Fox, June 1899, Harriman Alaska Expedition (W. R. Coe), 9 specimens.
Yakutat, June 19, 1899, Harriman Alaska Expedition (W. E. Ritter), 6 specimens.
Kodiak, July 3, 1899, Harriman Alaska Expedition (W. R. Coe), 3 specimens.

Young.—I have numerous small specimens from the region of Point Pinos, Monterey Bay, granite shore. These range in length, introvert extended, from 10 to 30 mm. They vary in skin color from pale translucent to medium brown, sometimes ochraceous, sometimes grayer in tone. There is as much variation as in large specimens in the extent of the preanal area of enlarged papillae and in the size of the terminal and preanal papillae, but in all cases these are conspicuously enlarged. The papillae of the distal part of introvert seem to be a little more conspicuous than in the adult. The transverse bands of yellowish or reddish brown are present on the introvert of nearly all specimens but the spots on the trunk are uncommon. The number of rings of the hooks is as few as 12, more often 15 or 16, less often as

many as 25. Out of about 100 examples only one (length 20 mm.) has the large number attributed to juveniles of some species; in this case there are 75, interrupted here and there as if hooks were being shed, but the first 13 rows are intact. There are 11 or 12 tentacles and the nuchal organ is conspicuous.

A specimen with trunk 8 mm. long has 21 anastomosing muscle bundles; the internal anatomy is a miniature of that of large specimens.

Variations.—The principal variations are external and concern the color, the size and shape of the larger tubercles of the anal region and posterior extremity, and the introvert hooks.

The glandular papillae are best seen in light-colored, small or medium sized specimens. They form low conical eminences with a blunt teatlike extremity. The circular brown portion containing the platelets is the upper two-thirds of the papilla, which is delimited by longitudinal and transverse shallow skin grooves forming roughly quadrilateral or roundish areas. The papillae are ordinarily separated by two or three times their own diameter but in fully extended specimens the space becomes greater. The preanal and terminal tubercles are the same shape but three or four times larger than those of the dorsum of the trunk. In very large specimens, particularly in those from Humboldt Bay, the preanal tubercles become very horny, large, and some of them are compressed entirely out of the original conical form. These are more often seen in the darkest brown specimens. The enlarged preanal papillae have the same arrangement of platelets as other papillae.

Irrespective of spotting, the skin color varies from no scattered pigment (pale pinkish gray, translucent) to pale sepia modified by ochraceous or yellowish tints; thence to deeper neutral or reddish brown, to a dark brown (Humboldt Bay). In tide pools of Monterey Bay the palest to the medium brown forms occur, but none of the darkest have been found. The paratypes are medium brown and this general tone predominates in specimens from Washington to Alaska, although some fairly light examples are present (San Juan Islands, Wash.; Clayoquot Sound, British Columbia; Cape Fox, Alaska). The Kodiak specimens are rather darker than "medium brown," and lighter than the deepest brown specimens from Humboldt Bay, Calif.

The 200 specimens from this locality occurred in mud of a quiet bay and are all large (upward of 130 mm. long). They are about half and half medium brown (often reddish) and dark umber-brown, the introvert much lighter and crossed dorsally by reddish-brown stripes. The integument of the trunk is thick and the skin rough, coriaceous. It may be that the darker color is in part due to staining by organisms in the mud. Those examined were all females.

The specimens from Crescent City are medium sized or small, and all are of the pale variety. On the other hand, the Ensenada examples are as dark as the paratypes.

Specimens from a colony of the hydrocoral *Allopora californica* are the pale variety, but those dredged off Point Pinos, Calif., in 46 to 56 fathoms (*Albatross* station 4551) are all well pigmented, medium brown. The same is true of the specimens from 10 fathoms off Santa Cruz.

Finally the darker pigment spots of the trunk are of irregular occurrence and are certainly of no specific importance.

Remarks.—Through similarity of habit, hooks, and internal structure there are six species of *Phascolosoma* more closely related to one another than to others of the genus. These are *granulatum*, *nigrescens*, *puntarenae*, *agassizii*, *japonicum*, and *scolops*.

Two specimens of *Ph. japonicum* from Aikawa, Rikuzen, Japan, are superficially very similar to pale examples of *agassizii*. Selenka's colored figures (1883, pl. 2, figs. 18, 19) might serve to illustrate some of the variations of *agassizii*. Evidently the hooks are as variable as in *agassizii*. They are the same size and shape, and the clear streak follows about the same course but has no expanded portion (as is sometimes the case in *agassizii*). There is a clear triangular area at the base but this is not indicated in Selenka's figure (1883, fig. 145) or in Sato's (1930, p. 10). The papillae of *japonicum* have obviously *larger* platelets, occupying a wider zone. The Aikawa specimens agree with Sato's figures (1939, p. 384). Internally the only tangible difference is the absence of a coecum. The fixing muscle is almost exactly the same as in *agassizii*; the nephridia are anchored to the same extent, the origin of the retractors varies within the limits of *agassizii*; and the longitudinal muscle bands show no significant difference.

I examined an example of *Phascolosoma japonicum* from Ucluclet, Vancouver Island, upon which Chamberlin (1920, p. 5d) based his record. It is clearly one of the variations of *agassizii*, lacking the essential characters of *japonicum;* that is, the clear streak of hook (pl. 38, fig. 23) has a slight swelling; the platelets of the dermal papillae are as in other examples of *agassizii;* there is an intestinal coecum. I have no means of checking the record of *japonicum* from the Queen Charlotte Islands. The 10 specimens from this locality that I examined are all *agassizii*.

Phascolosoma agassizii (including *puntarenae*) has been recorded from many localities all over the world. Wilhelm Fischer (1922a, p. 7) sums up the distribution. "The species is already known from all tropical and temperate seas." In the Indian Ocean he lists Ceylon, the Laccadive and Maldive Islands, Mauritius, Sumatra,

Timor; Sharks Bay and Rottnest Island, western Australia; in the Java Sea, Billiton and Nordwachter Islands; in the Pacific, Sydney (Port Jackson), Eimeo, and Tahiti; in the Atlantic and Mediterranean, Bermuda and Villefranche.

I doubt whether any of these records are valid for *Phascolosoma agassizii* as defined in this paper. Some of them may reasonably refer to *Ph. puntarenae*, a tropical species that has been confused with *agassizii*, a cool- or cold-water form. Fischer (1922a, pl. 1) gives figures of hooks from Sharks Bay (fig. 5), Port Jackson (fig. 6), Panama (fig. 7), and California (fig. 8). Fischer's figures 7 and 8 represent hooks of *puntarenae* and *agassizii* as understood in this paper, although as represented the light streak has too slight a swelling to be quite typical of Panamic specimens while it is over-emphasized in the California example (where it is often absent). These two Fischer regards as *agassizii*, as also the quite different Australian examples, which do not seem to me to represent either *puntarenae* or *agassizii*. Fischer's paper is exceptional in giving figures of details. Without them it is impossible to evaluate records.

To those who hold that *agassizii* and *puntarenae* constitute a single species, it is necessary to point out that the latter name has 7 years priority.

PHASCOLOSOMA PUNTARENAE Grube

PLATE 36, FIGURES 1, 2; PLATE 37, FIGURES 1–3; PLATE 39, FIGURE 3

Phascolosoma puntarenae GRUBE, 1859, p. 13.
Phascolosomum puntarenae DIESING, 1859, p. 761.
Sipunculus (*Phymosomum*) *puntarenae* QUATREFAGES, 1866, p. 624.
Phascolosoma agassizii KEFERSTEIN, partim, 1866, p. 218; 1867, p. 46, pl. 6, fig. 8.
Phymosoma agassizii var. *puntarenae* SELENKA, 1883, p. 79.
Physcosoma agassizii, partim, authors.

Diagnosis—Size small to medium (68 mm.), in general form similar to *Phascolosoma agassizii* but with slightly longer papillae, especially on dorsum of introvert; with transverse bars of brown on introvert; tentacles 24; hooks in upward of 100 rings and half rings, but deciduous and the number not constant. Differing from *agassizii* in structure of hooks, in having generally slightly larger papillae with fewer and less crowded platelets on their periphery, and in having a longer, more conspicuous coecum. Differing from *Ph. nigrescens*, to which it is rather closely related, chiefly in the less sharply bent hooks.

Description.—The largest specimen (Espíritu Santo Island) measures 68 mm. in length, with introvert extended but not fully relaxed. It more nearly resembles *Phascolosoma nigrescens* than it does *Ph. agassizii*. The papillae are enlarged in the same areas as in *agassizii* but the difference is not so marked, as the minor papillae are a little

larger and slightly more protuberant and give a somewhat shaggy appearance. The platelets of the papillae are less numerous and, except near the center, are less crowded than in *agassizii*. Two examples from a small Panama specimen are shown on plate 36, figures 1 and 2. In the large specimen some of the papillae have the platelets similar to figure 3 (*agassizii*); but more often they look like figure 3 with the smaller platelets removed, while the larger platelets have an irregular, crenulated periphery. (See Selenka, 1883, pl. 9, fig. 137, *nigrescens*.)

There are about 25 complete rings of hooks; and back of these, about 30 more dorsal half rings, with a few scattered hooks on the ventral side of the introvert. In a Panama specimen (length 33 mm.) there are about 100 rings with a scattering of hooks beyond. In adult *agassizii* the hook rings seldom exceed 25 and are often 17 to 20, but in *nigrescens* the number varies from 30 to 120 (Selenka, 1883, p. 11). The hook of *puntarenae* (Selenka's pl. 1, figs. 1–3) is very different from that of *agassizii* in the position of the clear streak and in having a larger expanded portion of this streak. If the hook were slightly more bent it would closely resemble that of *nigrescens* (see pl. 39, fig. 2, and Selenka, 1883, pl. 9, figs. 130, 135). Even the slight hump (*a*) characteristic of *nigrescens* is indicated in *puntarenae*.

There are 24 tentacles surrounding the large heart-shaped nuchal organ (pl. 39, fig. 3; compare pl. 36, fig. 4). The fold or ridge surrounding the tentacles and mouth is colorless. Below this is the ring collar immediately in front of the hook zone.

The color is pale yellowish brown, the trunk and dorsal side of introvert irregularly peppered with dark brown papillae. The hooks form a brown zone behind the collar; then there is a dorsal half-ring of dark brown, followed by 4 or 5 transverse dorsal bands of much lighter reddish brown. The Guaymas specimen has a reddish brown trunk without spots and about 10 dark-brown dorsal bands on introvert.

In this typical section of the genus the internal anatomy does not vary greatly from species to species. There are 20 to 30 longitudinal muscle bands that anastomose freely, the lesser number being near the front of the trunk. The ventral retractors have a broad base arising from bands 2 to 7 on the right and 2 to 9 on the left. The fixing muscle arises in the same place as in *Ph. agassizii* and its attachment to the esophagus and to the rectum is the same. One point of difference is the coecum, which is papilliform, several times longer than thick, and relatively larger than in *agassizii*. A precisely similar coecum was found in a specimen of *Ph. nigrescens* from the Hawaiian Islands. The reddish brown nephridia are larger than in any *agassizii* examined. The proximal end is inflated. They reach nearly to the end of the body, only the proximal third being anchored. The Hawaiian

specimen of *nigrescens* has reddish brown nephridia with conspicuously inflated proximal portion, but the distal part is badly contracted. The contractile vessel has no villi, and there is no sign of them in the Hawaiian specimen of *nigrescens*, although Selenka states that they are present in that species.

Type locality.—Puntarenas, Costa Rica.

Distribution.—Panama to Gulf of California.

Specimens examined.—Five, as follows:

Espíritu Santo Islands, near La Paz, Baja California, March 1940, E. F. Ricketts, 1 specimen.

Guaymas, Mexico, Miramar Beach, rocky, Feb. 10, 1948, W. H. MacGinitie, 1 specimen.

Bay of Panama, F. H. Bradley, 1866, 3 specimens.

Remarks.—This species seems to me to be of tropical derivation and closely related to *Ph. nigrescens* Keferstein, 1865, whereas *agassizii* is primarily a cold-water species, which reaches its best development both in size and number of individuals from Alaska to northern California. South of Monterey Bay large specimens are apparently absent or else are to be found in cooler water off shore.

PHASCOLOSOMA DENTIGERUM (Selenka and de Man)

PLATE 39, FIGURES 4–7

Phymosoma dentigerum SELENKA and DE MAN, 1883, p. 67, pl. 1, fig. 9; pl. 9, figs. 118–123.

Diagnosis.—Medium-sized, slender species with a dorsal preanal area of conspicuously enlarged, dark-brown, sharp conical tubercles, some of which are usually directed backward; a similar area of sharp conical tubercles at posterior extremity; other papillae small; rings of hooks few; hooks sharply bent, with a median, often slightly dilated, clear streak and a separate large triangular clear area.

Description.—The specimens are all slender; one with introvert fully extended measures: trunk 30 mm., introvert 20 mm. A larger example, with introvert retracted, would attain a length of 67 mm. General color of preserved specimens yellowish gray, pale sepia, or pinkish lavender. Longitudinal muscle bands visible through body wall. Papillae of ventral surface very small, gradually increasing in size to middorsal region, where in anterior half of trunk they are still small and of unequal size. Posteriorly, however, they rapidly increase in size to become circular, conical, sharp, dark brown tubercles against the pale ground color. Immediately in front of the anus is a ring zone of the same sharp brown tubercles. These are continued forward on the introvert as a middorsal band for about half to two-thirds its length, usually, but not always, in conjunction with a skin color of burnt-sienna, which makes the area very conspicuous. The largest tubercles are at the base of the introvert and are directed

backward in varying degrees, sometimes assuming the stature of short, sharp spines. However, there is much variation. In little specimens and a few adults the enlarged spines remain symmetrically conical. The dorsal light-reddish-brown pigment of the spine area is continued forward, sometimes subdivided into transverse patches of color, becoming darker in the narrow zone of the hooks. The platelets of the smaller papillae are numerous, close to one another, and decrease in size from the central clear pore zone to the periphery, where they are little more than granules. In the outer zone there are no larger platelets among the small ones, as in *Ph. agassizii*. In the larger specialized papillae, or tubercles, of the introvert the platelets are relatively larger, thicker, more crowded and heavily pigmented. Immediately around the pore zone the platelets are usually a little smaller than those over the remainder of the tubercle. On the anterior half of the introvert the papillae are elliptical in outline, become gradually very small (0.07 to 0.1 mm. long diameter) and the platelets are reduced to granules, retreating more and more to the central portion immediately surrounding the pore.

The hooks form 16 to 21 dark-brown rings, the posterior rings being sometimes incomplete from loss of hooks. The hooks are characteristic in having the terminal portion sharply bent, in combination with an unusually large, clear, triangular space, which is separated from the median clear streak (not merged with it as in *puntarenae* and *nigrescens*). Note the dilation of the clear streak. The so-called tooth on the concave border of the hook may be well developed or absent.

In three adults the tentacle counts are 12, 13, 15. Tentacles more or less pigmented with dark olive. The nuchal organ is large and similar to that of *agassizii*. The smooth zone between circumoral collar or ridge and the collar just in front of the hook area is divided into an uncolored anterior half and a brown half.

The internal anatomy differs from that of *agassizii* only in minor details. The longitudinal muscle bands anastomose more freely in some individuals than in others. There are 18 to 20 bands at the origin of ventral retractors. The latter have a broad base arising from the muscle bundles 3–6, varying to 2–5, the dorsal retractors, about the same distance in front as *agassizii*, arise on left from 4–6 or 5–7 and on right from 6–7 or 4–6. The fixing muscle arises on the left of the nerve cord at the same place as in *agassizii* and, forking, is attached to the esophagus and to the intestine a short distance posterior to the coecum. The spindle muscle is strong and is very similar to that of *agassizii*.

There is a well-developed subspherical coecum. The intestinal spiral is of moderate length with about 16 to 18 single whorls.

The nephridia vary in length, sometimes reaching to the origin of the ventral retractors. The proximal third or half is anchored by a mesentery. They open between the third and fourth longitudinal muscles at the same level as the anus. A short distance in front of them the muscle bundles unite to form a single sheet. The contractile vessel is very slender, without villi. The brain has two eye spots. The eggs are elliptical, 0.11 by 0.09 mm. Each end is slightly truncated, with an indentation in the thick shell.

Type locality.—Philippine Islands.

Distribution.—Indo-Pacific, tropical. The paucity of records as compared with *Ph. scolops* is probably due to the habits of *dentigerum* in hiding in crannies of coral rock.

Specimens examined.—As follows:

El Pulmo Reef, Baja California, southeast shore of end of peninsula, in interstices of living coral, *Pocillopora*, March 19, 1940, E. F. Ricketts, 10 specimens.

Puerto Escondido, Gulf of California, Baja California, under boulders, March 25, 1940, E. F. Ricketts, 1 specimen.

San Carlos Bay, Gulf of California, Baja California, among rocks, March 30, 1940, E. F. Ricketts, 17 specimens.

Puerto Refugio, Angel de la Guardia Island, Gulf of California, Baja California, April 2, 1940, E. F. Ricketts, 2 specimens.

Puerto Penasco, Mexico, Dec. 24, 1947, W. H. MacGinitie, 15 specimens.

Panama Bay, Panama, F. H. Bradley, 1866, 3 specimens.

Remarks.—This species varies considerably in ground color, which is usually light brownish or grayish, and in the intensity of brown on the introvert. I have examined specimens from Eniwetok Atoll, Marshall Islands, Hawaiian Islands (Laysan, Kauai, Hawaii) and from the Gulf of Davao, Mindanao. The extent of development of the toothlike tubercles of introvert varies greatly. In the Laysan specimen they are symmetrical, sharp cones, as in some of the Baja California examples. The tubercles of the ventral side of the introvert and the papillae of the trunk are much larger in the Laysan specimen. The specimens described above probably constitute a distinct race inhabiting the Pacific coast within the tropics and subtropics.

Ten Broeke (1925, p. 88) has described from Caracas Bay, Venezuela, *Phascolosoma microdentigerum*, which differs from *dentigerum* in the smaller size of its spines and the presence of little villi on the contractile vessel. Trunk only 10 mm. long. Fischer (1922b, p. 11) records *dentigerum* from Barbados, reef.

PHASCOLOSOMA ANTILLARUM Grube and Oersted

PLATE 39, FIGURES 8, 9

Phascolosoma antillarum GRUBE and OERSTED, 1859, p. 117.—KEFERSTEIN, 1865b, p. 435, pl. 31, fig. 11, pl. 33, fig. 37.

Phymosoma antillarum SELENKA, 1883, p. 57, pl. 7, fig. 93–96.

Physcosoma antillarum GEROULD, 1913, p. 420, pl. 62, figs. 19, 20.—STEINBECK and RICKETTS, 1941, p. 346, pl. 16, fig. 2.

Diagnosis.—Habit robust; trunk brown from numerous low convex papillae, large and crowded at posterior end and in anal region; introvert abruptly cream color, only about one-third trunk length; no hooks; tentacles long, very numerous; superficially resembling *Dendrostomum.* Length, including tentacular crown, 57 mm.; trunk, to anus, 37 mm.; anus to cephalic collar, 16 mm.; width of tenacular crown, 10 mm.

Description.—Selenka gives the number of tentacles 50 to 80; in my specimen there are nearer 200, pale cream color (as is most of introvert) with only an indication of brown spotting near the tips. The expanded tentacular disk, to accommodate the large number of its peripheral tentacles, is thrown into regular folds (pl. 39, fig. 9) as happens in fully expanded sea anemones having a large number of tentacles. The form of the centrally located nuchal organ is shown in this figure. The mouth is overhung by the tentacles. Directly below it the cephalic collar has a slight projection on its otherwise even edge.

The skin of the trunk is divided into subquadrate areas by furrows. In each area is a deep-brown convex subcircular papilla composed of numerous closely placed chitinous platelets, while between these closely spaced papillae the cream-colored skin contains *separated* dark-brown platelets. The ventral papillae are slightly larger than the dorsal; in most species of the genus the reverse is true. At each end of the trunk the papillae are much larger than elsewhere. At the posterior end and on the ventral side of the anal region, the whole of each papilla area becomes filled with densely crowded brown platelets. Dorsally in the anal region the large papillae are slightly separated and often of irregular form. Abruptly, just in front of the anus, the papillae become much smaller, elongate conical, sharp, and decrease in size toward the second collar.

The muscle bundles of the inner layer anastomose. There are about 20 in the anterior part of the trunk and 28 to 30 posteriorly. Dorsal retractors arise only a short distance in front of the ventrals at the beginning of the posterior third of the trunk. The two muscles of each side soon unite. In a strongly contracted specimen there is hardly any separation and the animal appears to have only two retractors arising near the posterior end of the body. The degree of separation is like that of *Phascolosoma asser* (Selenka, 1883, fig. 97). There is one fixing muscle arising on the left of the nerve cord in about the same place as in *agassizii.* It is attached to the rectum in front of the coecum and some of its fibers pass into the spindle muscle. At the point of its attachment to the rectum a part of the muscle continues and is attached to the esophagus as it forms the first coil.

The contractile vessel carries very numerous conspicuous slender villi, which extend from just behind the head to the first coil of the

spiral. They are not simple but are dichotomously branched three or four times so that they appear to arise from the vessel in clusters, very much as in *Golfingia macginitiei*.

The nephridia are very long and are attached except for a short terminal portion. They open between the third and fourth muscle bundles. The nerve cord is loosely attached by its nerves. The eye spots are very inconspicuous (not "deutliche" as Selenka describes them). The specimen from Espíritu Santo Island contained many apparently fully formed elliptical eggs 0.1 by 0.12 mm. The shell is thick (0.05 mm.) and by transmitted light appears to be cross striated (pl. 39, fig. 8).

Type locality.—Puerto Cabello, Venezuela.

Distribution.—Florida (Key West, Loggerhead Key); West Indies (Cuba, Porto Rico, St. Thomas, St. Croix, Barbados, Jamaica); Colombia; Venezuela; Dutch Guiana; Brazil. In the Pacific: Gulf of California; Costa Rica; Panama; Chili; Hawaii (Halape); Riukiu Islands (Amami Oshima, Naha, Itoman, Tinensaki).

Specimens examined.—Five specimens:

Point Lobos, Espíritu Santo Island, Baja California, under boulders, March 20, 1940, E. F. Ricketts, 1 specimen.
East of La Paz, interstices of dead coral, E. F. Ricketts, 1 specimen.
Bay of Panama, F. H. Bradley, 1866, 3 specimens.

Remarks.—On account of its more sturdy habit, short introvert, and conspicuous crown of tentacles this species superficially resembles a *Dendrostomum* and is unlike any other *Phascolosoma* from the eastern Pacific.

LITERATURE CITED

BAIRD, WILLIAM.
1868. Monograph of the species of worms belonging to the subclass Gephyrea. . . . Proc. Zool. Soc. London, 1868, pp. 76–114, pls. 9–11.

BENHAM, W. B.
1922. Gephyrea inermia. Australasian Antarctic Expedition, 1911–14, under the leadership of Sir Douglas Mawson. Scientific Reports, series C.—Zoology and botany, vol. 6, pt. 5, 23 pp. 1 pl.

BLAINVILLE, HENRI MARIE DUCRATAY DE.
1827. Dictionnaire des sciences naturelles, Vers, vol. 49.

CHAMBERLIN, RALPH VARY.
1919. Notes on the sipunculids of Laguna Beach. Pomona Coll. Journ. Ent. and Zool., pp. 30–31.
1920. The Gephyrea collected by the Canadian Arctic Expedition, 1913–18. Report of the Canadian Arctic Expedition, vol. 9, pt. D, 21 pp., 1 pl.

COLLIN, ANTON.
1892. Gephyreen gesammelt von Herrn Stabsarzt Dr. Sander auf der Reise S. M. S. *Prinz Adalbert*. Arch. Naturg., Jahrg. 58, vol. 1, pp. 177–182, pl. 11.
1901. Die Gephyreen der deutschen Expedition S. M. S. *Gazelle*. Arch. Naturg., Jahrg. 67, Festschr. Ed. von Martens Beiheft, pp. 299–306.

DANIELSSEN, D. C., AND KOREN, JOHAN.
1880. New northern Gephyrea. Ann. Mag. Nat. Hist., ser. 5, vol. 6, pp. 462–465.
1881. Den Norske Nordhavs-Expedition (1876–78). Gephyrea.

DIESING, CHARLES MAURICE.
1851. Systema helminthum . . ., vol. 2, Vindobonae.
1859. Revision der Rhyngodeen. Sitzb. Math. Akad. Wiss. Wien, Nat. Cl., vol. 37, pp. 719–782, 3 pls.

FISCHER, WILHELM.
1895. Die Gephyreen des naturhistorischen Museum zu Hamburg. Abh. Geb. Naturw. Naturwissenschaftlicher Verein in Hamburg, vol. 13, pp. 1–24, 1 pl.
1914. Weitere Mitteilungen über die Gephyreen des Naturhistorischen (Zoologischen) Museums zu Hamburg. Mitt. Naturh. Mus. Hamburg, Jahrg. 31, pp. 1–28, 1 pl.
1916. Die Gephyreenausbeute der deutschen Tiefsee-Expedition (1898–1899). Zool. Anz., vol. 48, pp. 14–20.
1919. Gephyreen der Südwestküste Australiens. Zool. Anz., vol. 50, pp. 277–285, 6 figs.
1922a. Gephyreen des Reichsmuseum zu Stockholm. Arch. Zool., vol. 14, No. 19, 39 pp. 4 pls.
1922b. Westindische Gephyreen. Zool. Anz., vol. 55, pp. 10–18, 5 figs.
1922c. Gephyreen der deutschen Tiefsee-Expedition. Wiss. Ergeb. deutschen Tiefsee-Exped., vol. 22, pp. 1–26, 2 pls.
1926a. Sipunculiden und Echiuriden der Hamburger Südsee-Expedition 1908–1909. Mitt. Zool. Staatsinst. Zool. Mus., Hamburg, vol. 42, pp. 104–117, pl. 3.
1926b. Sipunculoidea und Echiuroidea. Die Fauna Südwest-Australiens, vol. 5, pt. 3, pp. 199–215, pl. 2.
1928. Über zwei neue Siphonosoma-Arten der Württ-Naturalien-Sammlung zu Stuttgart. Zool. Anz., vol. 76, pp. 138–143, 2 figs.

FISHER, WALTER KENRICK.
1928. New Sipunculoidea from California. Ann. Mag. Nat. Hist., ser. 10, vol. 1, pp. 194–199, pls. 6–8.
1947. New genera and species of echiuroid and sipunculoid worms. Proc. U. S. Nat. Mus., vol. 97, pp. 351–372, pls. 8–15.
1950a. The sipunculid genus *Phascolosoma*. Ann. Mag. Nat. Hist., ser. 12, vol. 3, pp. 547–552.
1950b. Two new subgenera and a new species of *Siphonosoma* (Sipunculoidea). Ann. Mag. Nat. Hist., ser. 12, vol. 3, pp. 805–808, 1 pl.

GEROULD, JOHN HIRAM.
1913. The sipunculids of the eastern coast of North America. Proc. U. S. Nat. Mus., vol. 44, pp. 373–437, 5 pls., 16 figs.

GRUBE, E., and OERSTED, A. S.
1859. Annulata Oerstediana. Vid. Medd. naturh. Foren. Kjøbenhavn for 1858.

HÉRUBEL, MARCEL A.
1908. Récherches sur les sipunculides. Mém. Soc. Zool. France, 1907, pp. 107–418, pls. 5–10.

IKEDA, IWAJI.
1904. The Gephyrea of Japan. Journ. Coll. Sci., Imp. Univ. Tokyo, vol. 20, art. 4, pp. 1–87, 4 pls.
1924. Further notes on the Gephyrea of Japan, with descriptions of some new species from the Marshall, Caroline and Palau Islands. Jap. Journ. Zool., vol. 1, pp. 23–44, pl. 1.

KEFERSTEIN, WILHELM.
1862. Beiträge zur Kenntniss der Gattung *Phascolosoma*. Zeit. Wiss. Zool., vol. 12, pp. 35–51.
1865a. Beiträge zur anatomischen und systematischen Kenntniss der Sipunculiden. Zeit. wiss. Zool., vol. 15, pp. 189–209.
1865b. Beiträge zur anatomischen und systematischen Kenntniss der Sipunculiden. Zeit. wiss. Zool., vol. 15, pp. 404–445, pls. 31–33.
1866. Untersuchungen über einige amerikanischen Sipunculiden. Nachr. Ges. wiss. Göttingen, pp. 215–228.
1867. Untersuchungen über einige amerikanischen Sipunculiden. Zeit. wiss. Zool., vol. 17, pp. 44–55, pl. 6.

KESTEVEN, H. L.
1903. A new species of *Dendrostoma*. Rec. Australian Mus., vol. 5, No. 1, pp. 69–73, pl. 7, fig. 7.

KOREN, JOHAN, and DANIELSSEN, D. C.
1875. Bidrag til norske Gephyreers Naturhistorie. Nyt. Mag. Naturv., vol. 21, pp. 108–138.
1877. *In* Sars, Fauna littoralis Norvegiae, pt. 3. Contribution to the natural history of the Norwegian Gephyreae, pp. 111–151. Bergen.

LAMBERT, J.
1900. Étude sur quelques échinides de l'infralias et du lias. Bull. Soc. Sci. l'Yonne, vol. 53, pt. 11, 1899, pp. 3–57.

LANKESTER, E. RAY.
1885. *Golfingia MacIntoshii*, a new sipunculid from the coast of Scotland. Trans. Linn. Soc. London, ser, 2, vol. 2, pp. 469–474, pls. 55, 56.

LEUCKART, FRÉDÉRIC SIGISMOND.
1828. Breves animalium quorumdam maxima ex parte marinorum descriptiones. Heidelberg.

LINNAEUS, CARL.
1766. Systema naturae, ed. 12.

MÖBIUS, K.
1875. Vermes. *In* Commission zur wissenschaftlichen untersuchung der deutschen meere in Kiel. Jahresbericht, 1872–73, pp. 150–170, 1 pl.

OSTROUMOV, A. A.
1909. Sur les géphyrées du nord de la Mer du Japon. Ann. Mus. Zool. Akad. Sci. St. Pétersbourg, vol. 14, pp. 319–324.

PEEBLES, FLORENCE, and FOX, DENIS L.
1933. The structure, functions, and general reactions of the marine sipunculid worm *Dendrostoma zostericola*. Bull. Scripps Inst. Oceanography, techn. ser., vol. 3, pp. 201–224, 11 figs.

POURTALÉS, LOUIS FRANÇOIS DE.
1851. On the Gephyrea of the Atlantic coast of the United States. Proc. Amer. Assoc. Adv. Sci., 5th meeting, pp. 39–42.

QUATREFAGES, JEAN LOUIS ARMAND DE.
1866. Histoire naturelle des annelés marins et d'eau douce, vol. 2. Paris.

ROULE, L.
1907. Annélides et Géphyriens. Expéditions scientifiques du *Travailleur* et du *Talisman* . . ., vol. 8, pp. 1–102, pls. 1–10.

SARS, M.
1851. Beretning om en i Sommeren 1849 foretagen zoologisk Reise i Lofoten og Finmarken. Nyt. Mag. Nat., vol. 6, pp. 121–211.

SATÔ, HAYAO.

1930. Report of the biological survey of Mutsu Bay. 15. Sipunculoidea. Sci. Rep. Tôhoku Imp. Univ., ser. 4, Biology, vol. 5, No. 1, pp. 1–40, figs. 1–15, pls. 1–4.

1934. Report on the Sipunculoidea, Echiuroidea and Priapuloidea collected by the Sôyô-Maru Expedition of 1922–1930. Sci. Rep. Tôhoku Imp. Univ., ser. 4, Biology, vol. 9, pp. 1–32, figs. 1–31, pl. 1.

1935. Sipunculoidea and Echiuroidea of the West Caroline Islands. Sci. Rep. Tôhoku Imp. Univ., ser. 4, Biology, vol. 10, pp. 299–329, figs. 1–17, pls. 2–4.

1937. Echiuroidea, Sipunculoidea and Priapuloidea obtained in northeast Honshû, Japan. Saito Ho-on Kai Museum, Research Bull. No. 12, pp. 137–176, pls. 1–4.

1939. Studies on the Echiuroidea, Sipunculoidea and Priapuloidea of Japan. Sci. Rep. Tôhoku Imp. Univ., ser. 4, Biology, vol. 14, pp. 339–460, figs. 1–60, pls. 19–23.

SELENKA, EMIL.

1885. Report on the Gephyrea collected by H. M. S. *Challenger*. . . . Zoology, vol. 13, pt. 36, pp. 1–25, pls. 1–4.

1897. Die Sipunculiden-Gattung *Phymosoma*. Zool. Anz., vol. 20, p. 460.

SELENKA, EMIL; DE MAN, J. G.; and BÜLOW, C.

1883. Die Sipunculiden. Reisen im Archipel der Philippinen von Dr. C. Semper, Theil 2, Bd. 4, Abth. 1.

SHIPLEY, ARTHUR E.

1898a. A report on the Sipunculoidea collected by Dr. Willey at the Loyalty Islands and in New Britain. Zool. Results A. Willey, pt. 2, pp. 151–160, pl. 18.

1898b. Report on the gephyrean worms collected by Mr. J. Stanley Gardiner at Rotuma and Funafuti. Proc. Zool. Soc. London, 1898, pp. 468–473, pl. 37.

SLUITER, C. PH.

1882. Beiträge zu der Kenntniss der Gephyreën aus dem Malayischen Archipel. Zweite Mittheilung. Systematische und Anatomische beschreibung einiger neuen und wenig bekannten Sipunculiden. Nat. Tijdschr. Nederlandsch-Indië, vol. 41, pp. 84–110, pl. 1; pp. 148–152, 3 pls.

1886. Beiträge zu der Kenntniss der Gephyreën aus dem Malayischen Archipel. Nat. Tijdschr. Nederlandsch-Indië, vol. 45, pp. 472–517, 4 pls.

1891. Die Evertebraten aus der Sammlung des Königlichen Naturwissenschaftlichen Vereins in Niederländish Indien in Batavia. Zugleich eine Skizze der Fauna des Java-Meeres, mit Beschreibung der neuen Arten. Nat. Tijdschr. Nederlandsch-Indië, vol. 50, pp. 102–123, 2 pls.

1900. Géphyriens . . . provenant des campagnes de l'*Hirondelle* et de la *Princesse Alice*. Résultats des campagnes scientifiques . . . Albert Ier, Prince souverain de Monaco, fasc. 15, 31 pp. 3 pls. Monaco.

1902. Die Sipunculiden und Echiuriden der *Siboga*-Expedition . . ., vol. 25, 53 pp., 4 pls.

SPENGEL, JOHANN WILHELM.

1898. Der Name *Physcosoma*. Zool. Anz., vol. 21, p. 50.

1912. Einige Organisationsverhältnisse von Sipunculusarten und die Bedeutung für die Systematik dieser Tiere. Verh. deutsch. zool. Ges., vol. 22, pp. 261–272.

1913. Zur Organisation und Systematick der Gattung *Sipunculus*. Verh. deutsch. zool. Ges., vol. 23, pp. 68–78.

STEINBECK, JOHN, and RICKETTS, EDWARD F.

1941. Sea of Cortez. A leisurely journal of travel and research.

STEPHEN, A. C.

1934. The Echiuridae, Sipunculidae, and Priapulidae of Scottish and adjacent waters. Proc. Roy. Phys. Soc., vol. 22, pp. 159–185, 1 fig.

1941. The Echiuridae, Sipunculidae and Priapulidae collected by the ships of the *Discovery* Committee during the years 1926 to 1937. *Discovery* Reports, vol. 21, pp. 237–260, pls. 7, 8.

1942. The South African intertidal zone and its relation to ocean currents. Ann. Natal Mus., vol. 10, pp. 245–256, pl. 11.

1948. Sipunculids. B. A. N. Z. Antarctic Research Expedition, Reports, ser. b, vol. 5, pt. 4, pp. 213–220, pl. 1.

TEN BROEKE, ADA.

1925. Westindische Sipunculiden und Echiuriden. Bijdragen tot de Kennis der Fauna van Curaçao. Resultaten eener reis van Dr. C. J. van der Horst in 1920. Bijdr. Dierk. Art. Magis, 24 afl., pp. 81–96, 25 figs.

THÉEL, HJALMAR.

1905. Northern and Arctic invertebrates in the collection of the Swedish State Museum (Riksmuseum). 1. Sipunculids. Kungl. Svenska. Vet.-Akad. Handlingar, vol. 40, No. 1, 130 pp., 15 pls.

1911. Priapulids and Sipunculids dredged by the Swedish Antarctic Expedition, 1901–1903. . . . Kungl. Svenska. Vet.-Akad. Handlingar, vol. 47, No. 1, 36 pp., 5 pls.

WESENBERG-LUND, ELISE.

1930. Priapulidae and Sipunculidae. . . . The Danish *Ingolf*-Expedition . . ., vol. 4, 44 pp., 6 pls.

1932. The Godthaab Expedition 1928. Gephyrea. Medd. om Grønland, vol. 79, No. 3, 18 pp., 9 figs.

1933. The collections of gephyreans in the Royal Museum of Natural History of Belgium. Bull. Mus. Roy. Hist. Nat. Belgique, vol. 9, No. 6, pp. 1–16, pls. 1–4.

1937. The zoology of east Greenland. Gephyreans. Medd. om Grønland, vol. 121, No. 1, pp. 1–25, figs. 1–7.

1939. Gephyreans from Swedish waters in the Museum of Natural History of Gothenburg. Medd. Göteborgs Mus. Zool. Avdelning. 80. Göteborg Kungl. Vet.-och Vitterhets-Samhälles Handl., ser. b, vol. 6, No. 6, pp. 1–35.

EXPLANATION OF PLATES

Plate 18

Sipunculus nudus Linnaeus

1, A portion of the internal structure to demonstrate the extra intestinal spiral *A*, which has been dissociated from the regular spiral *B* and drawn to the left; *X* and *Y* are for identification of the same points in plates 10 and 11, Fisher, 1947; × 2.

2, Frontal view of oral disk and tentacular fold of a small specimen from Newport Bay, Calif. The dotted circle indicates limit of oral disk, external to which is the tentacular fold, subdivided into lobes; × 6.

3, Tentacular fold of a large specimen from Anaheim Landing, Calif., having the dorsal lobes well developed (left side omitted); × 5. Vertical line of dashes indicates sagittal plane.

4, Longitudinal section of a portion of body wall to show integumental coelomic canals (*IC*); × 8. Circular muscle bundles in solid black. Longitudinal muscle (*LM*), seen from side, dotted. Arrows indicate passage to body coelom.

5, Cross section of body wall, cut slightly on bias; × 8. Four integumental canals are shown. The arrows are in the slits, shown in 4, between the circular muscle bundles. On the right the cut is slightly to one side of slits. Longitudinal muscles in solid black.

A, Accessory intestinal spiral; *B*, regular spiral; *C*, coecum, *CV*, dorsal contractile vessel (ventral in solid black); *DT*, dorsal tentacles; *M*, mouth; *N*, nephridium; *RD*, dorsal retractor muscle; *RV*, ventral retractor; *S*, spindle muscle; *W*, wing muscles of rectum (the stippled bodies are the "Zottenbildungen" of Selenka); *X* and *Y*, second and first bends of accessory intestinal spiral.

Plate 19

Xenosiphon branchiatum (Fischer)

1, Anterior sixth of a specimen, with introvert extended, from Panama. It has been opened a little to the left of middorsal line and spread out so that the dorsal retractors are unnaturally spread apart and the rectum is on extreme right instead of being in middorsal line. The esophagus actually bends to left and is attached behind and in a line with the left dorsal retractor; × 2. Figures denote muscle bands to right and left of nerve cord.

2, Sketch of another specimen, from Panama, in which the introvert is partly withdrawn to show altered position of protractors (*P*); × 1.

3, Brain and the bushy frons (cerebral organ); × 10.

4, Six dermal rectangles at margin of papularium of La Paz specimen; × 10. In this specimen the cuticular welts above the canals alone show well, the detail in upper left rectangle being supplied from a Panama specimen. The next rectangle has no papillae but the irregular canal shows through the cuticle. The lower left shows at each end of canal the pores (arrows) which lead eventually to coelom.

5, A single rectangle of skin of Panama specimen about 25 mm. anterior to papularium showing a skin canal gorged with material; × 20. At either end the dark spot marks the canal to coelom.

A, Anus; *C*, intestinal coecum; *CV*, dorsal contractile vessel; CV^1, ventral contractile vessel; *Fr*, cerebral organ or frons; *I*, introvert; *N*, nephridium; *NC*, nerve cord; *O*, esophagus, its mesenteries cross-hatched; *P*, protractors of head; *R*, rectum; *RD*, dorsal retractor; *RV*, ventral rectractor; *S*, spindle muscle; *T*, tentacles, *Z*, filamentous organ described in text.

Plate 20

Siphonosoma ingens (Fisher)

1, Head of small specimen (Elkhorn Slough, Monterey Bay, Calif.) drawn from life; × 8.

2, Anterior end of paratype, × 1, showing the introvert partly invaginated and retractors in contracted state.

3, Portion of 2 enlarged; × 2. The left root (S [1]) of spindle muscle has been severed.

4, Nephrostome of a specimen from Newport Bay and associated coelomic papillae; × 10.

5, Coelomic papilla; × 30.

6, Brain of paratype; × 10.

CP, coelomic papillae (Keferstein bodies); *CV*, dorsal contractile vessel; *F*, fixing muscle; *I*, introvert; *N*, nephridium; *NC*, nerve cord; *NO*, position of nuchal organ at anterior end of dorsal double series of tentacular lappets; *O*, esophagus; *RD*, dorsal retractors; *RV*, ventral retractors; *S*, spindle muscle; *S′*, S″, lateral roots of spindle muscle; *W*, wing muscle of rectum.

Plate 21

Siphonosoma ingens (Fisher), types

1, 2, Anterior half of body; × 1.5. The top of figure 2 is a continuation of the bottom of figure 1. This specimen is unusually well relaxed. The coelomic papillae have been omitted and the muscle bands are only slightly indicated in order to avoid confusion of lines.

3, Same specimens; × 3. Point where the esophagus joins and is fastened to the ascending intestine at beginning of rectum, showing relations to spindle muscle (*S*) and its lateral roots, *S′*, *S″*; the fixing muscle to esophagus is omitted.

4, A segment of the esophagus and four retractors opposite the wing muscles of rectum to show the lateral mesenteries of esophagus; × 5. *M*, right mesentery. Other lettering as for plate 20.

Plate 22

Siphonides rickettsi, new species

1, Map of visceral anatomy, constructed from both type and paratype; × 5. The section shown includes the portion of whole animal between horizontal lines of figure 4. Only the ventral muscle bands of paratype are shown in lower part of figure. The nephridia are from type. Coecum and wing muscles of rectum not lettered and only a few coils of the intestinal spiral are indicated. The simple contractile vessel along esophagus is shown by dotted line.

2, One of the hooks of introvert; × 500.

3, A gland from ridge between consecutive rings of hooks; × 500.

4, Diagram of entire animal; × 1. Between the horizontal lines is portion shown in figure 1; the dot is anus and the two vertical lines are the ventral retractors.

5, Left nephridium of paratype, which has a short anterior lobe, showing attachment to body wall, the large nephrostome, and cleavage of longitudinal muscles. The origin of left dorsal retractor (*RD*) is from muscle bands 2 and 3 with a few fascicles from 1 and 4; × about 10.

6, The mammiform glands of skin, the upper two in profile; × 50. Probably normally all are capped by an elongate papilla as shown on left. It is sometimes brownish.

A, anus; *CF*, nephrostome; *F*, fixing muscle of intestine; *IS*, intestinal spiral; *N*, N^1, the two lobes of nephridium; *RD*, *RV*, dorsal and ventral retractors; *S*, spindle muscle.

Plate 23

1, *Golfingia margaritacea californiensis*, new subspecies. Dissection of paratype; × 7.5. 1, *a*, Two eggs of *californiensis* (larger) and two from Dutch Harbor specimen of *margaritacea;* × 7.5.

2, *G. margaritacea californiensis.* Central portion of visceral complex further enlarged. A section has been removed from the ventral retractors; and the base of the muscles is not shown.

3, *Golfingia margaritacea*, (Sars) Alaskan form, Dutch Harbor, Unalaska, × 4. Central portion of visceral complex to show the fixing muscles, 1 to 4 being normal. In specimen from Kilisnoo, 2 is double and an extra, 2, *a*, is present. In Kate Island, British Columbia, specimen, 4 is completely double. F^1 or F^2 are occasionally absent in Alaskan specimens, and F^3 and F^4 are sometimes attached to intestine close together.

A, anus; *C*, coecum; F^1 to F^4, fixing muscles; *N*, nephridium; *NO*, nuchal organ; *O*, esophagus; RD, dorsal retractor; *RV*, ventral retractor.

Plate 24

1, *Golfingia hespera* (Chamberlin): The animal, natural size; that on left with fully extended introvert, the other with introvert partly invaginated.

2, *G. hespera:* Central portion of visceral complex of figure 3; × 12. The nephridia are shown as hollow vesicles with posterior lobe removed and the nephrostomes (*N'*) as if walls were transparent.

3, *G. hespera:* Dissection of trunk of a specimen from Balboa, Calif., × 6, showing particularly the two nephridia distended by sperm.

4, *G. hespera:* Head with crown of tentacles, not fully expanded, surrounded by collar; × 40. 4, *a*, A line 0.25 mm. long.

5, *G. hespera:* A hook from one of the anterior rings, × 1,000.

6, *Golfingia margaritacea californiensis*, new subspecies: Two animals; × 2.

7, *G. margaritacea californiensis:* Frontal view of the oral disk and tentacles; × 20.

8, *G. margaritacea californiensis:* Glands at end of body seen by transmitted light; × 200.

A, anus; *C*, coecum; *M*, mesentery anchoring rectum; *N*, nephridium; *N'*, nephrostome; *NO*, position of nuchal organ; *R*, united retractor muscles, along dorsal side of which is esophagus; *RD*, dorsal retractor; *RV*, ventral retractor; *S*, spindle muscle.

Plate 25

1, *Golfingia elachea*, new species, × 5: Dissection to show principally the fixing muscles, 1 to 7, indicated in text as F^1 to F^7. A section has been removed from the right retractor and most of the right nephridium is omitted. The horizontal lines indicate posterior limit of introvert. 1, *a*. The holotype, × 1.

2, *G. elachea:* Three papillae from middle of introvert, one seen from top to show pore; × 200.

3, *G. elachea:* Four papillae from posterior part of trunk, × 200.

4, *G. laetmophila*, new species, type; × 2. The introvert is about one-half invaginated. *W*, wing muscles.

5, *G. laetmophila;* × 6. Detail of base of the retractors showing esophagus and one of its mesenteries on left. The faint line in middle of esophagus is the rudiment of the contractile vessel or its mesentery. *O*, esophagus.

6, *G. laetmophila;* × 200. Four introvert spinelets; *a* and *c* with only part of cortical layer adhering; *b*, cortical layer removed; *d*, perfect spine.

Plate 26

Golfingia macginitiei, new species

1, Holotype; × 3. The introvert is invaginated; right nephridium bent forward. The contractile vessel and villi hide esophagus, which is shown at right before entering intestinal spiral, only four coils of which are indicated.

2, Oral end of a double row of tentacles; × 50.

3, Holotype; × 1.

4, A dermal papilla from near end of body; × 200.

5, Part of a cluster of Polian villi, × 50, and, above, the tip of one of the branches, flattened under a cover slip; × 200.

6, Top of intestinal spiral and the rectum to show Polian villi distended with corpuscles. Fixing muscle F^2 is attached to esophagus.

C, coecum; *CV*, contractile vessel; F^1, F^2, fixing muscles; *I*, introvert; *IS*, intestinal spiral; *M*, eight short diagonal bands of muscle; *S*, spindle muscle; *T*, tentacles showing through thin skin; *V*, Polian villi along each side of contractile vessel.

Plate 27

1, *Dendrostomum pyroides* Chamberlin: A robust specimen from life; dorsal side; × 1. 1, *a*, same; skin from introvert showing hooks; × 25. 1, *b*, Same; a hook; × 50.

2, *Dendrostomum pyroides;* lateral view of preserved specimen, showing characteristic curvature of body; × 1.

3, *Dendrostomum perimeces* Fisher; lateral view of preserved specimen; × 0.75. 3, *a*. Skin from introvert just anterior to anus, showing the brown papillae; × 65.

Plate 28

1, *Dendrostomum perimeces* Fisher; Head of a specimen drawn from life, × 5, showing tentacles in natural feeding position, the smooth brown collar, the whitish sphincter zone, and behind this the anterior part of papillae zone.

2, *Dendrostomum pyroides* Chamberlin, × 5; View looking down upon mouth, showing base of the four groups of tentacles, the grooves leading to mouth, and the serrate border of grooves. Between the two dorsal tentacles is the nuchal organ, *N*. Preserved specimen.

Plate 29

Dendrostomum pyroides Chamberlin

1, Dissection viewed from above; × 2. The contractile vessel and Polian tubules are shown in solid black, but not all of the tubules are indicated.

2, Oral disk and bases of four groups of tentacles (1–1V); × 12. Specimen from Boca de la Playa, near Ensenada, Baja California.

3, Side view of esophagus greatly enlarged to show network of vessels arising from the contractile vessel (*CV*) and enveloping esophagus. At lower end of figure the origin of the Polian tubules of left side only is shown.

CV, contractile blood vessel; F^1–F^3 fixing muscles of gut; *G*, gonad; *NO*, nuchal organ; *O*, esophagus; *R*, left retractor.

Plate 30

1, *Dendrostomum zostericolum* Chamberlin. Ensenada, Baja California; oral disk and base of six tentacles (1–VI), × 6, to show pattern of food grooves and large upper lip, behind which is the nuchal organ (*NO*). 1,*a*, one of the small branches at base of tentacles; × 20.

2, *Dendrostomum hexadactylum* Sato, Monterey Bay, Calif. Spines from introvert; × 25.

3, *Dendrostomum dyscritum*, new species, paratype, Monterey Bay, Calif.; × 5. Contractile vessel above esophagus (*O*) showing the pattern of Polian tubules for comparison with *D. zostericolum*, in which the tubules are fewer and do not branch, at least not at the base.

4, *Dendrostomum perimeces* Fisher, × 200. Glands from posterior third of body to show the three sizes; the largest is seen somewhat from side.

Plate 31

Dendrostomum zostericolum Chamberlin

1, Dissection of specimen from Ensenada, Baja California; × 1. The rectum, shown on right, in its natural position would be middorsal above esophagus. Only 6 of the 11 Polian tubules have been completed. The oblique bands of muscle in body wall are indicated as gray lines. 1, *a*, is posterior end of body omitted from 1.

2, Side view of esophagus, × 5, to show contractile vessel and origin of Polian tubules.

3, Rectum and associated structures of figure 1, × 2.

4, A skin papilla from posterior third of body; × 200.

5, Papillae from dorsal side of introvert near anus; × 65.

A, position of anus; *C*, coecum; *CV*, dorsal contractile vessel; F^1–F^3, fixing muscles; *G*, gonad; *I*, intestinal spiral, *IA*, ascending gut of spiral; *ID*, descending gut; *N*, nephridium; N^1, nephrostome; *O*, esophagus; *O′*, postesophageal gut; *PT*, Polian tubules; *S*, spindle muscle; *W*, wing muscles.

Plate 32

Dendrostomum zostericolum Chamberlin

1, Dissection of a specimen from Ensenada, Baja California; × 2. In this example the postesophageal gut (O') is unusually long and does not start to coil around the ascending spiral at +, the usual place. The contractile vessel has 12 Polian tubules. Length of specimen 190 mm.

2, Detail of intestinal coecum and spindle muscle, showing mode of attachment of the latter to intestinal wall posterior to coecum.

3, View of the inside of base of left nephridium with nephridiopore in center and inner opening of nephrostome at upper left; × 10.

4, Nuchal organ; margin of oral disk above and a branch of a dorsal tentacle on right. 4, *a*. Brain × 10. *CO*, circumesophageal commissure; *t*, nerves to tentacles;

C, coecum; *CG*, ciliated groove; *CV*, dorsal contractile vessel; F^1–F^3, fixing muscles; *M*, mesentery of esophagus; *N*, nephridium; *N'*, nephrostome; *O'*, postesophageal intestine; *PT*, Polian tubules; *S*, spindle muscle; *W*, wing muscles of rectum.

Plate 33

Dendrostomum perimeces Fisher

1, Dissection of paratype; × 1. Note the very long intestinal spiral, few Polian tubules, relatively short nephridia; absence of fixing muscles (intestinal anchors). Oblique muscle bands of body wall are indicated.

2, Another specimen showing esophagus, contractile vessel, rectum, and top of intestinal spiral; × 2.

3, Enlargement of posterior end of contractile vessel of figure 1.

A, anus; *CV*, contractile vessel; *N*, nephridium; *O*, esophagus, *O'*, postesophageal intestine; *PT*, Polian tubules; *S*, spindle muscle; *W*, wing muscles.

Plate 34

Dendrostomum dyscritum, new species

1, Dissection of a specimen from Monterey Bay (see pl. 30, fig. 3); details of Polian tubules omitted. F^1–F^3, fixing muscles (see also figure 87); *G*, gonad.

2, Skin gland from posterior third of body; × 200.

3, Contracted specimen from near Point Conception; × 1.

4, One of the paratypes, Monterey Bay; × 1.

5, Detail of end of the intestinal spiral.

Plate 35

Dendrostomum lissum, new species

1, Type; × 4. The Polian tubules have been omitted for simplification and only upper coils of intestinal spiral are indicated.

2, Type; × 3. The dorsal branch of each dorsal tentacle has been removed to show the heart-shaped nuchal organ.

3, Two of the glands from body just anterior to the posterior dark area; × 200.

4, Oral disk and bases of the four or eight tentacles; × 6. The arrows indicate the primary radii.

A, anus; F^1–F^3, fixing muscles; *G*, gonad; *N*, nephridium; *N'*, nephridiopore; *NO*, nuchal organ.

Plate 36

1, 2, *Phascolosoma puntarenae* Grube, Panama. Dorsal papillae from postanal region, 0.105 by 0.14 mm.; × 200.

3, *Phascolosoma agassizii*, Keferstein; Monterey Bay, Calif. A dorsal papilla from postanal region, 0.2 by 0.24 mm., to show typical arrangement of platelets; × 200.

4, *Phascolosoma agassizii*; × 16. Dorsal view of head. The crown of 24 tentacles has been bent rather unnaturally dorsalward; nuchal organ in middle.

5, *Phascolosoma agassizii;* × 2. Large specimen from Humboldt Bay, Calif., to show origin of ventral retractors; nerve cord omitted from midventral line + +.

6, *Phascolosoma agassizii*; × 2. Dissection of a specimen from Bodega Head, Calif., near the type locality. A short section of esophagus has been removed to show attachments of fixing muscle *F* (*F′*, esophageal branch); *N*, nephridium.

Plate 37

Hooks of specimens from Panama to Humboldt Bay, Calif., for comparison. Measurements in millimeters; the first number is total height; the second is extreme width of base. Enlarged × 400.

1, 2, *Phascolosoma puntarenae* Grube, Panama; 0.059 × 0.07 and 0.05 × 0.05; *a*, the thickening of base similar to that of *Ph. nigrescens* (pl. 39, fig. 2).

3, *Phascolosoma puntarenae*, from Espíritu Santo Island, Baja Calif.; 0.0875 × 0.077.

4–15, *Phascolosoma agassizii* Keferstein:

4, San Quintin, Baja Calif.; 0.063 × 0.059.

5, Santa Rosa Island, Calif.; 0.07 × 0.07.

6, 7, Point Pinos, Monterey Bay, tide pool in granite rocks; 0.08 × 0.08 and 0.087 × 0.066.

8, Monterey Bay, from colony of Allopora, 50 feet depth; 0.06 × 0.06.

9, 10, Monterey Bay, common tide pool form from under granitic stones on fine sand or mud. From same specimen, 0.063 × 0.063 and 0.063 × 0.056.

11, Monterey Bay, at Hopkins Marine Station, form with dark purple brown introvert markings; 0.059 × 0.063.

12, Bodega Head; 0.059 × 0.059.

13, 14, Mendocino, from one of Keferstein's paratypes; 0.06 × 0.06 and 0.056 × 0.05.

15, Humboldt Bay, from a light colored specimen; 0.07 × 0.066.

Plate 38

Phascolosoma agassizii Keferstein

Figures of hooks for comparison, continued from plate 37:

16, 17, Humboldt Bay; same specimen as figure 15; 0.063 × 0.052 and 0.066 × 0.05.

18, Humboldt Bay; from one of the darkest brown specimens; 0.063 × 0.05.

19, 20 Crescent City, from same specimen; 0.059 × 0.059 and 0.052 × 0.056.

21, 22 Friday Harbor, Wash.; 0.077 × 0.08 and 0.063 × 0.063, different specimens.

23, Ucluclet, British Columbia; 0.07 × 0.07.

24, Huston Inlet, Queen Charlotte Islands; 0.073 × 0.073.

25, Sitka, Alaska; 0.073 × 0.07.

26, Kodiak, Alaska; 0.042 × 0.049.

27, 28 Cape Fox, Alaska, same specimen; 0.052 × 0.0595 and 0.056 × 0.05.

29, 30 Monterey Bay, vicinity of Point Pinos, from young specimen 20 mm. long, introvert extended, 0.038 × 0.031. Figure 30 is × 400 and 29, another hook, × 800.

31, Humboldt Bay, Calif. Modified papillae from preanal region of a large dark brown female specimen, × 20; at lower right a papilla in profile. The papillae are bent away from introvert.

Plate 39

1, *Phascolosoma agassizii* Keferstein, Humboldt Bay, Calif.; × 2. A specimen in which the fixing muscle has been strongly contracted so that the rectum is lengthened. *C*, coecum; *F*, fixing muscle; *F′*, its esophageal branch; *NC*, nerve cord; *RV*, left ventral retractor; *S*, anterior end of spindle muscle; *W*, wing muscles, *1*, *2*, *3*, et cetera, muscle bands to right and left of nerve cord.

2, *Phascolosoma nigrescens* Keferstein, *Albatross* station 4160, Hawaiian Islands; a hook 0.07 × 0.08 mm., × 400, for comparison with *Ph. puntarenae; a*, the thickening or fold in the basal plate characteristic of *nigrescens*.

3, *Phascolosoma puntarenae* Grube; tentacular crown, × 8; nuchal organ in middle.

4, *Phascolosoma dentigerum* (Selenka and de Man), San Carlos Bay, Baja California; × 30. Tubercles from dorsal surface of a contracted specimen, a short distance in front of anus which is below middle of figure.

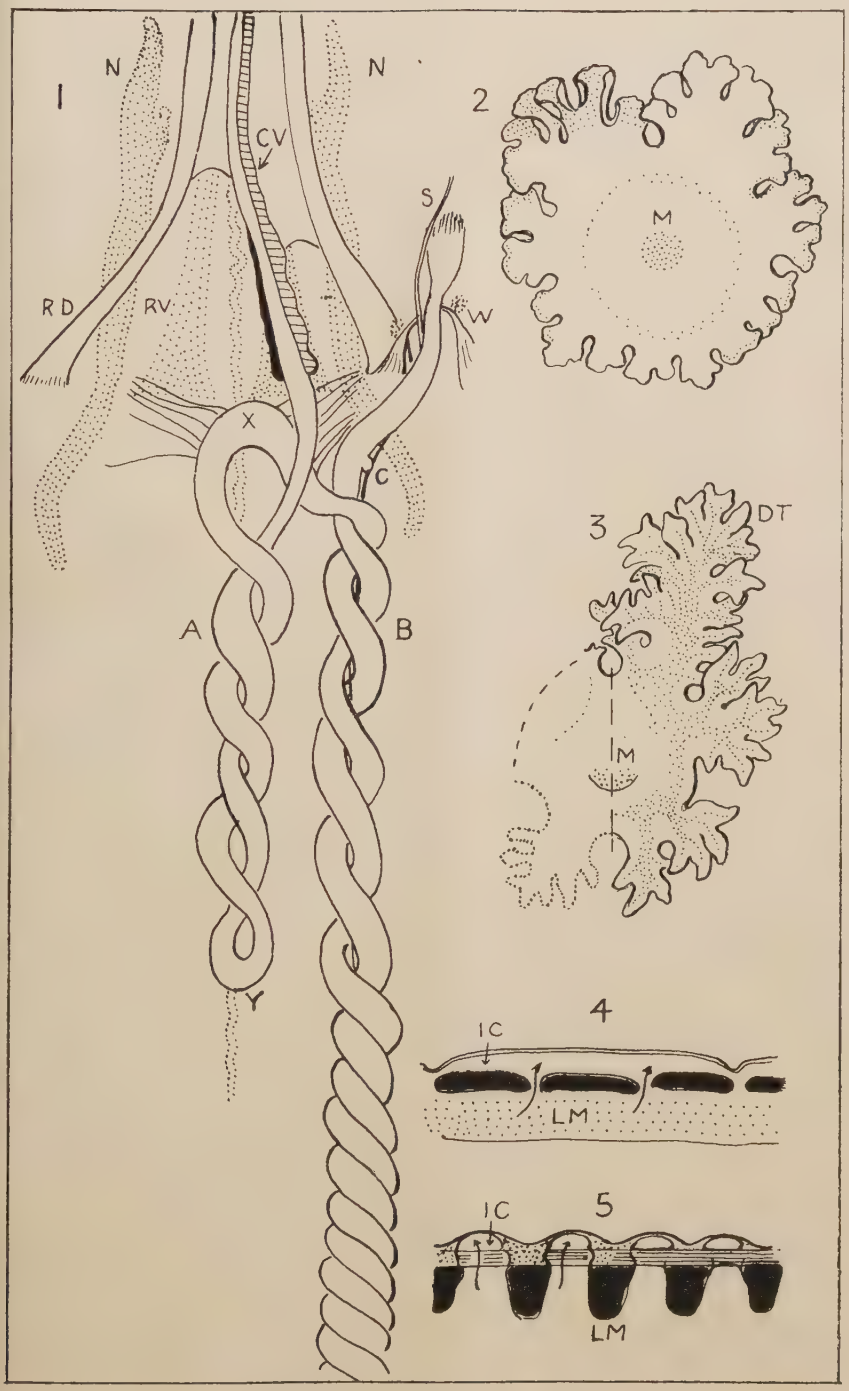
5, *Phascolosoma dentigerum;* × 2. Specimen from El Pulmo Reef, Baja California, to show areas of enlarged tubercular papillae. *A*, anus.

6, 7 *Phascolosoma dentigerum.* Two hooks, 0.056 × 0.063 and 0.056 × 0.05 mm.; × 400.

8, *Phascolosoma antillarum,* Grube and Oersted, an egg; × 100.

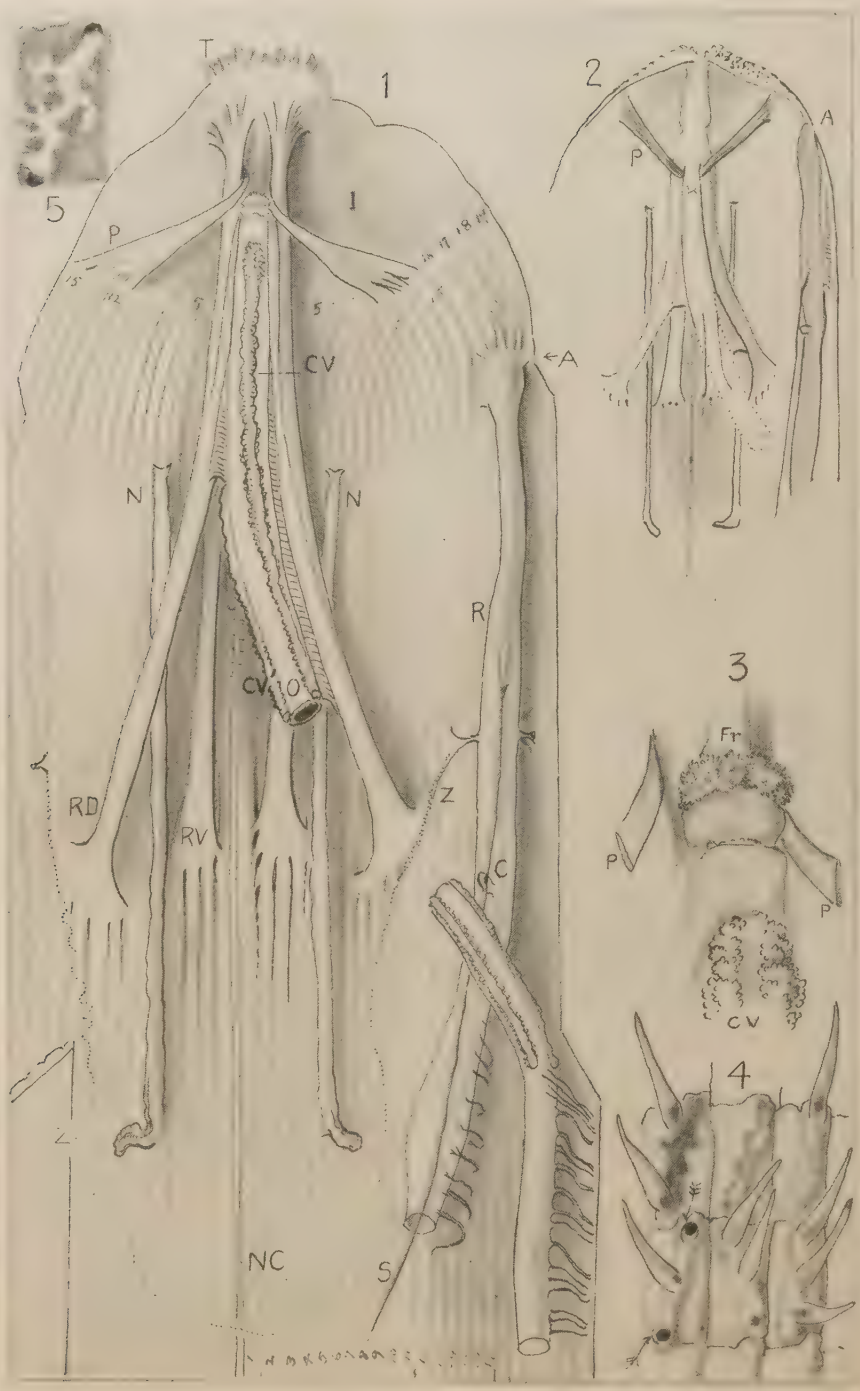
9, *Phascolosoma antillarum;* × 3. Dorsal aspect of anterior portion of specimen from Espíritu Santo Island, showing tentacular crown, the heart-shaped nuchal organ in center, second collar, introvert, and anal region (darker). An introvert papilla shown enlarged.

U. S. GOVERNMENT PRINTING OFFICE: 1952



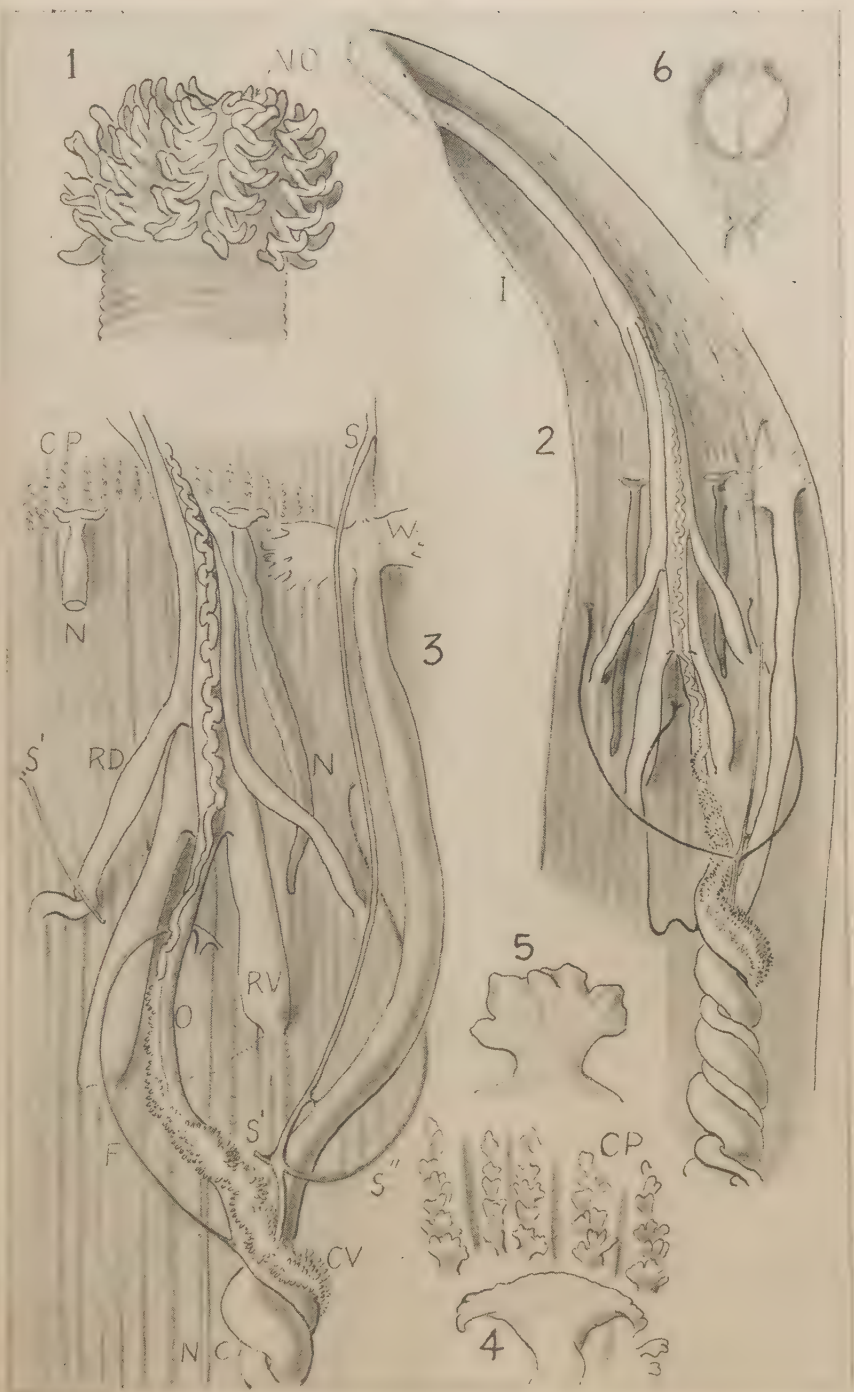
SIPUNCULUS NUDUS LINNAEUS.

SEE PAGE 441 FOR EXPLANATION.



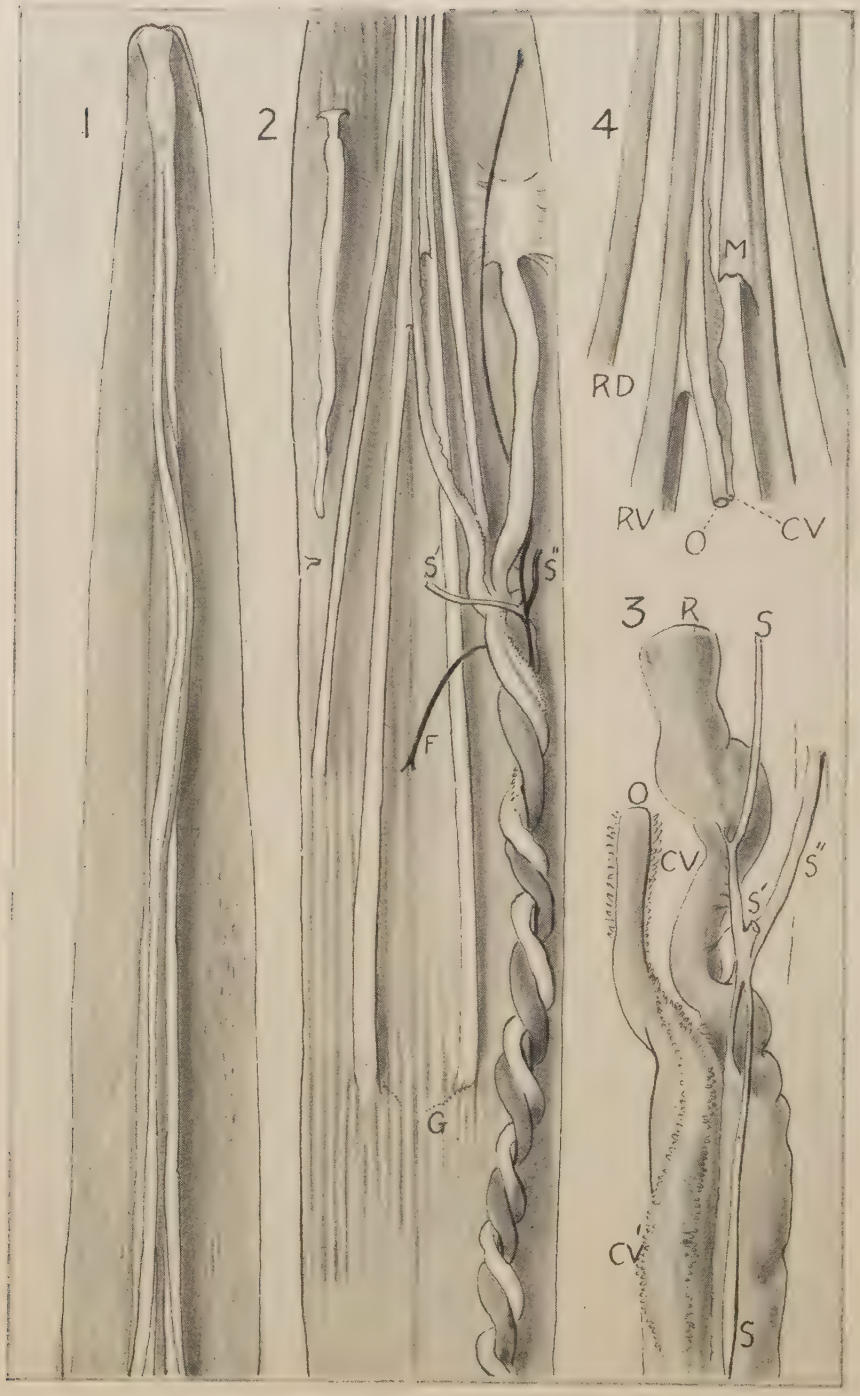
XENOSIPHON BRANCHIATUM (FISCHER).

SEE PAGE 441 FOR EXPLANATION.



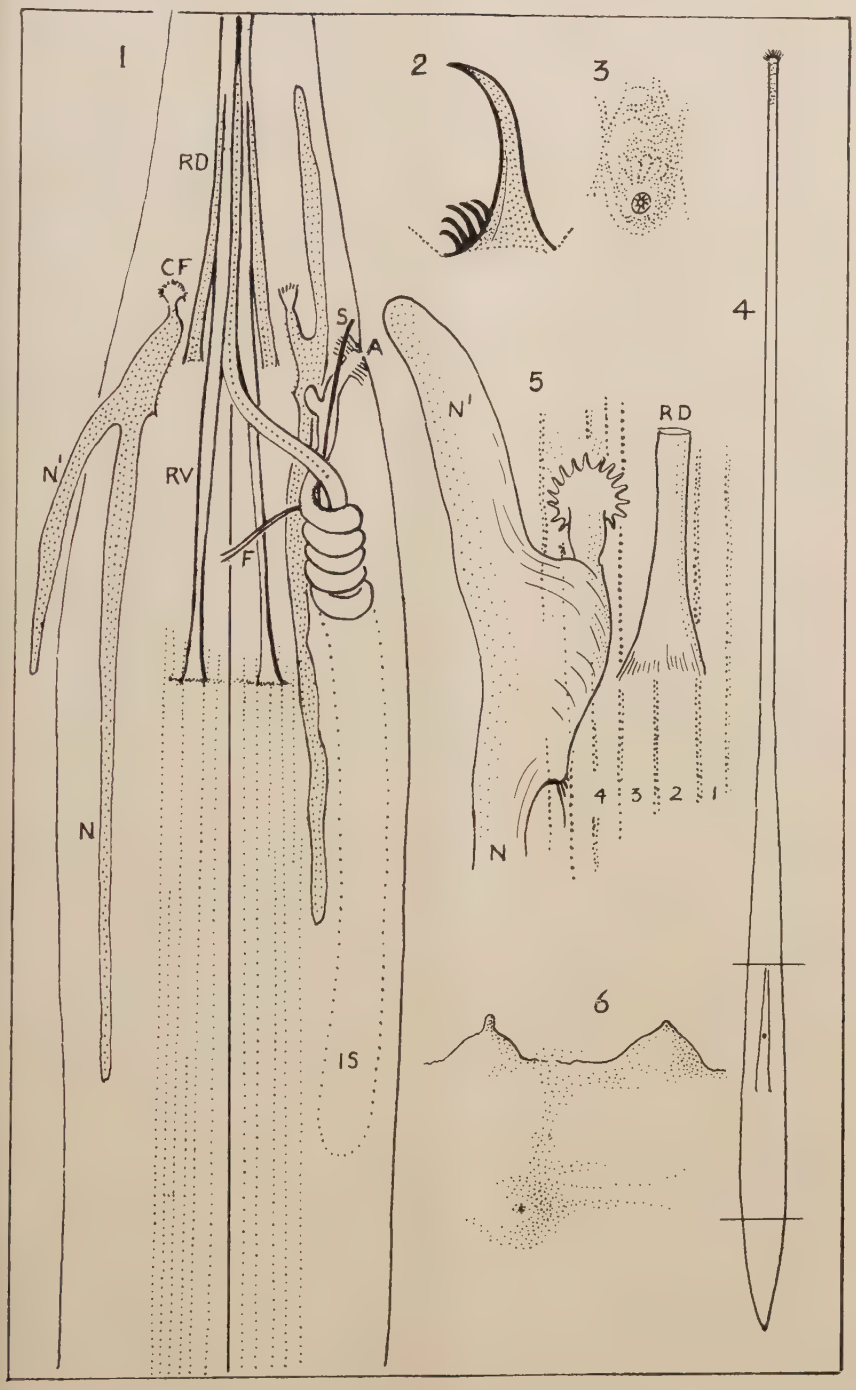
SIPHONOSOMA INGENS (FISHER).

SEE PAGE 442 FOR EXPLANATION.



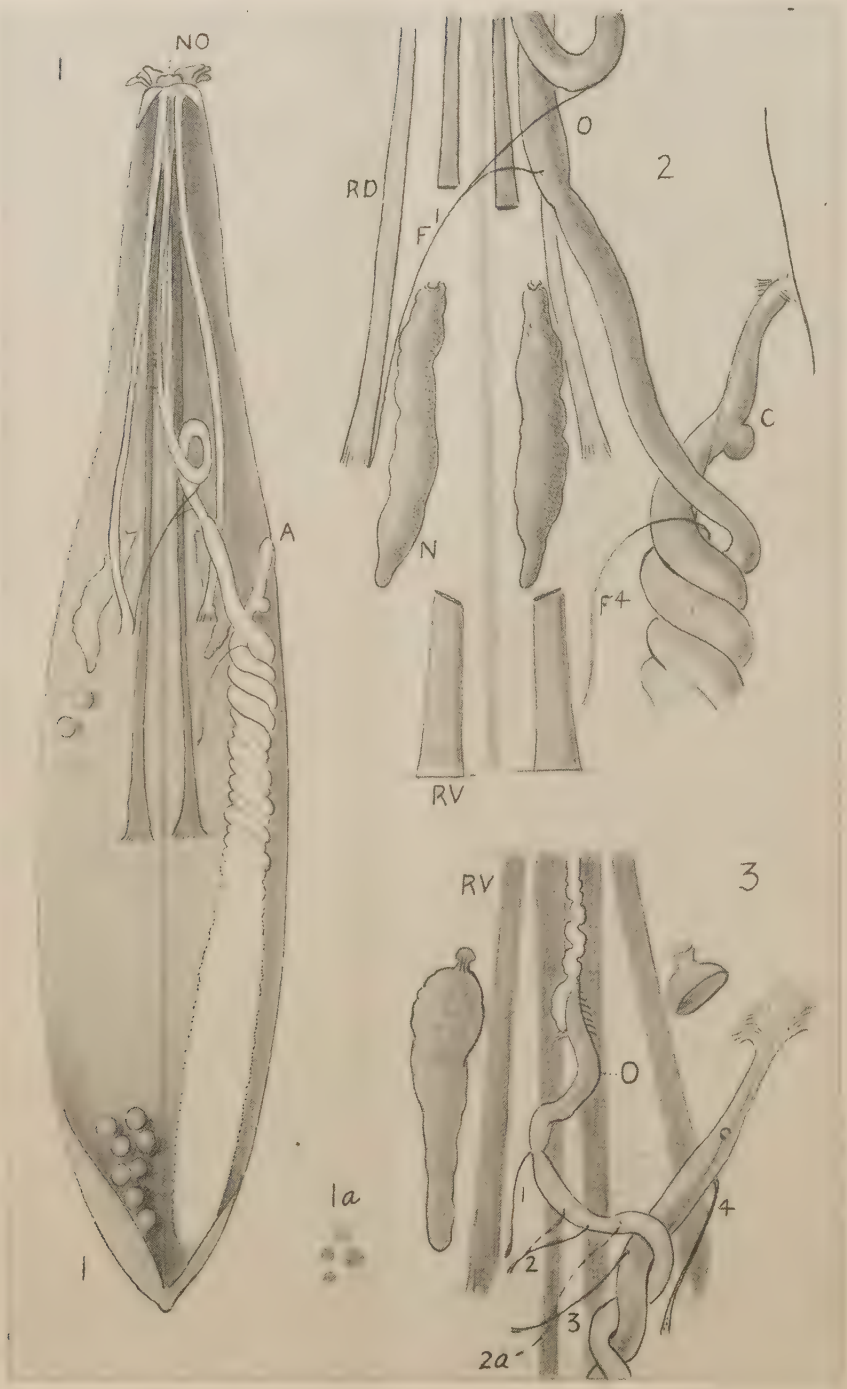
SIPHONOSOMA INGENS (FISHER), TYPES.

SEE PAGE 442 FOR EXPLANATION.



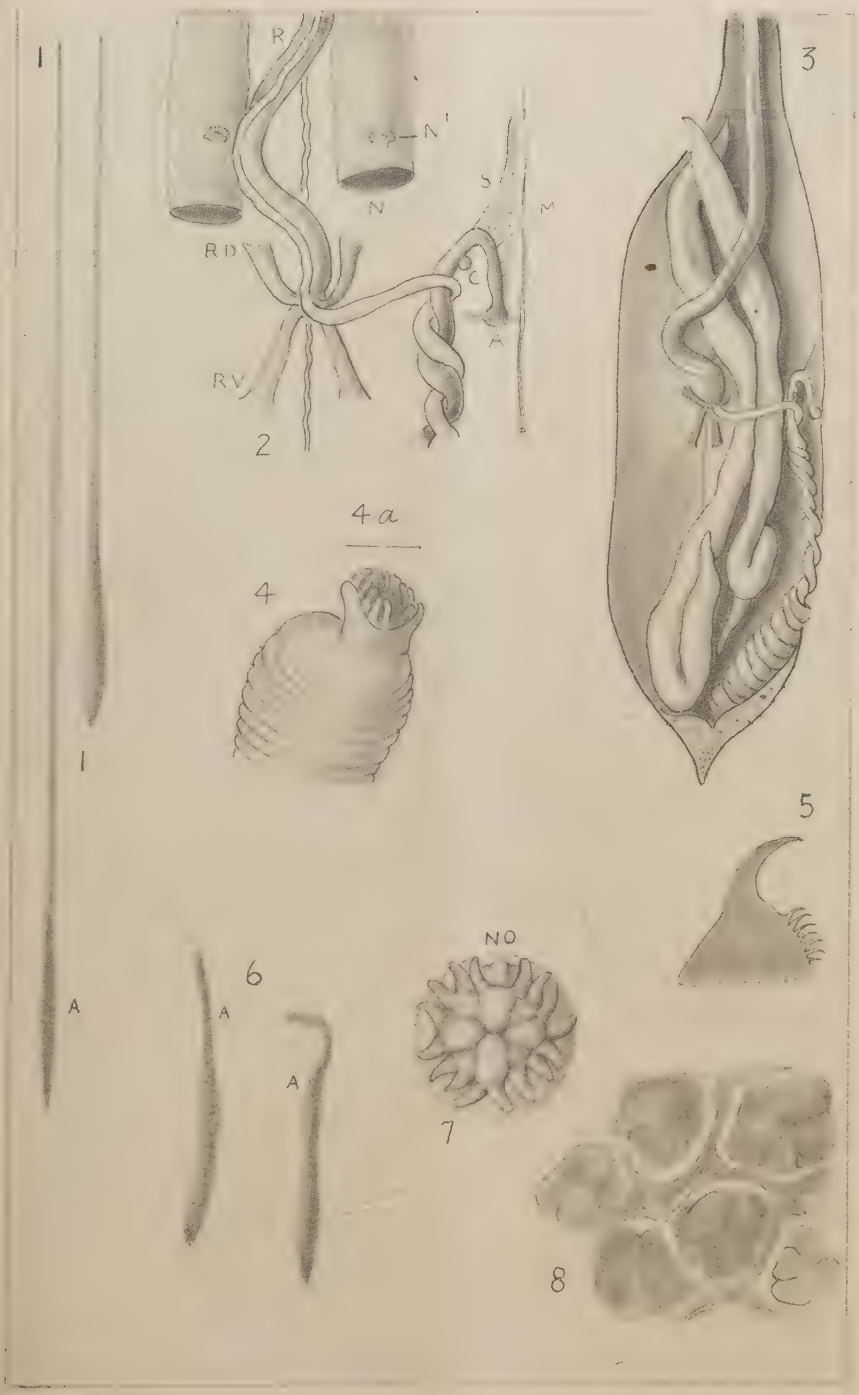
SIPHONIDES RICKETTSI, NEW SPECIES.

SEE PAGE 443 FOR EXPLANATION.



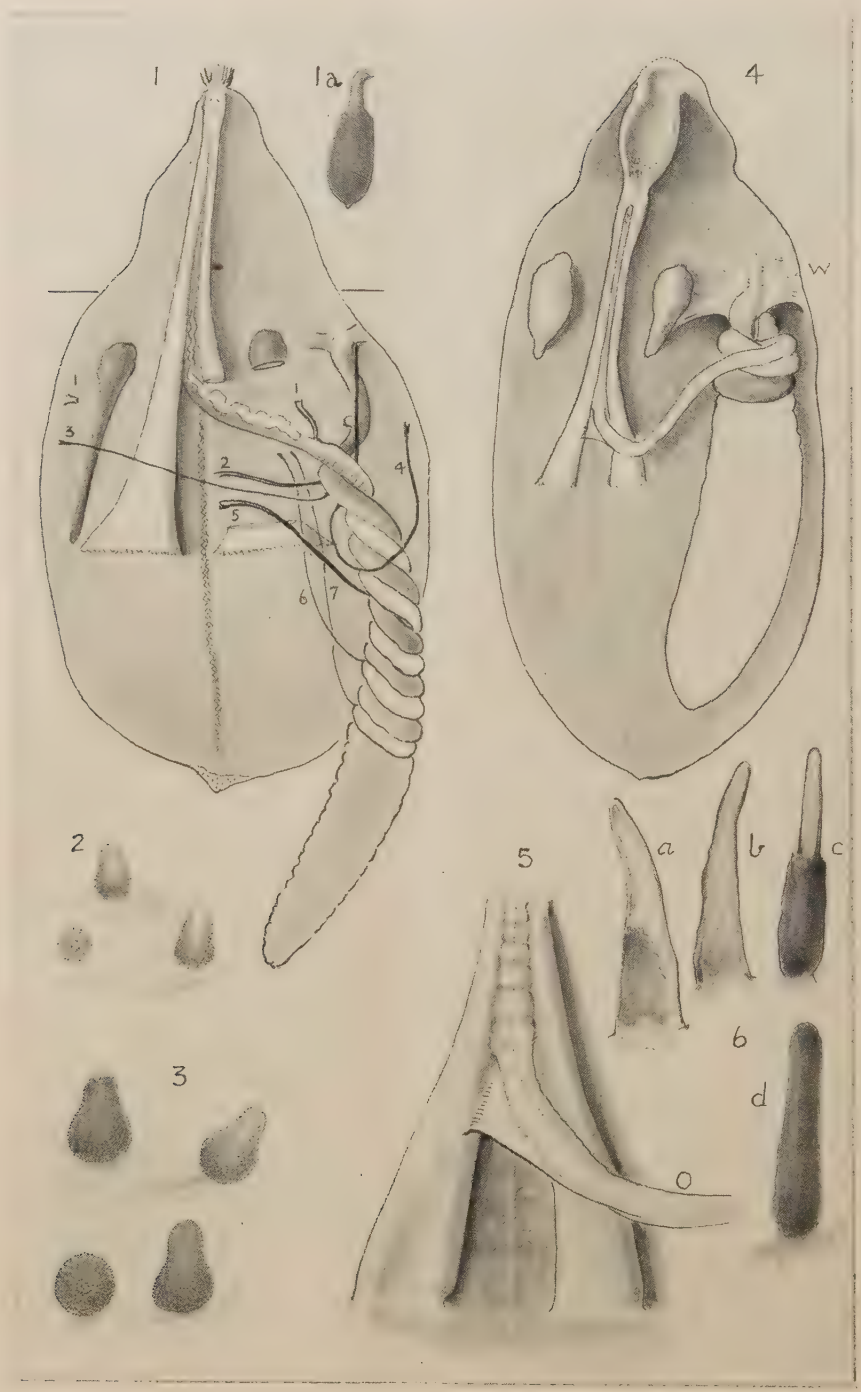
FORMS OF GOLFINGIA MARGARITACEA (SARS).

SEE PAGE 443 FOR EXPLANATION.



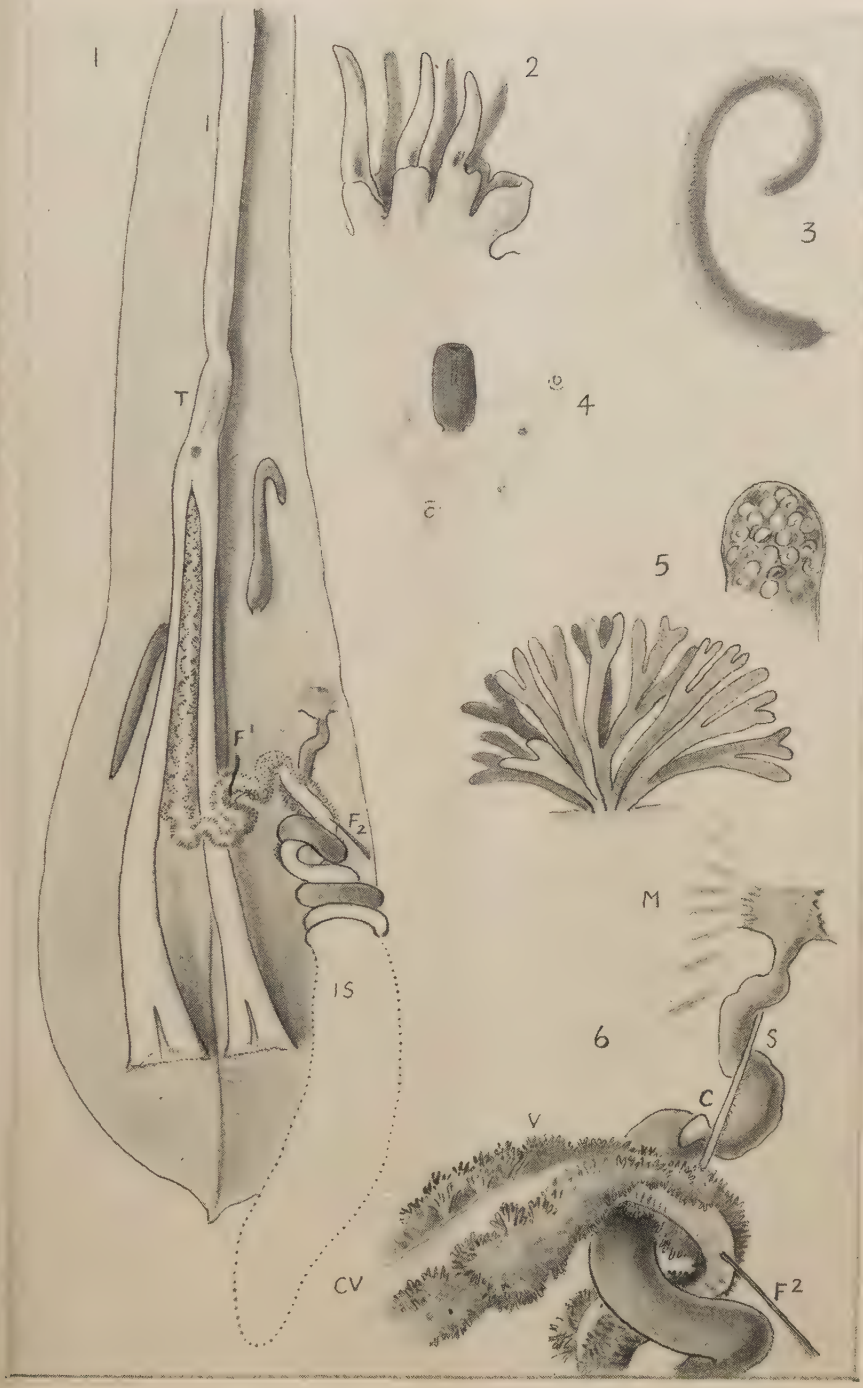
GOLFINGIA HESPERA (CHAMBERLIN) AND G. MARGARITACEA CALIFORNIENSIS, NEW SUBSPECIES.

SEE PAGE 444 FOR EXPLANATION.



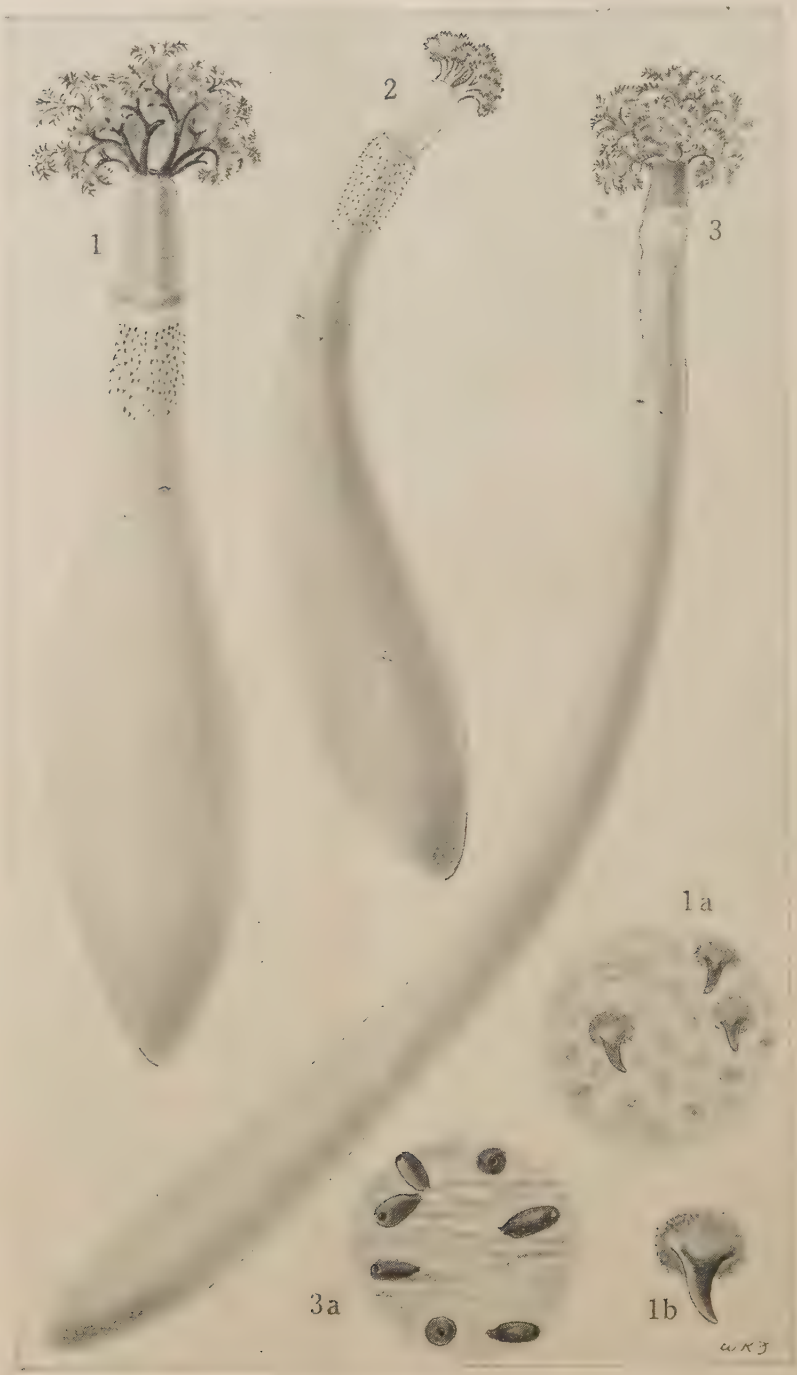
GOLFINGIA ELACHEA, NEW SPECIES, AND G. LAETMOPHILA, NEW SPECIES.

SEE PAGE 444 FOR EXPLANATION



GOLFINGIA MACGINITIEI, NEW SPECIES.

SEE PAGE 445 FOR EXPLANATION.

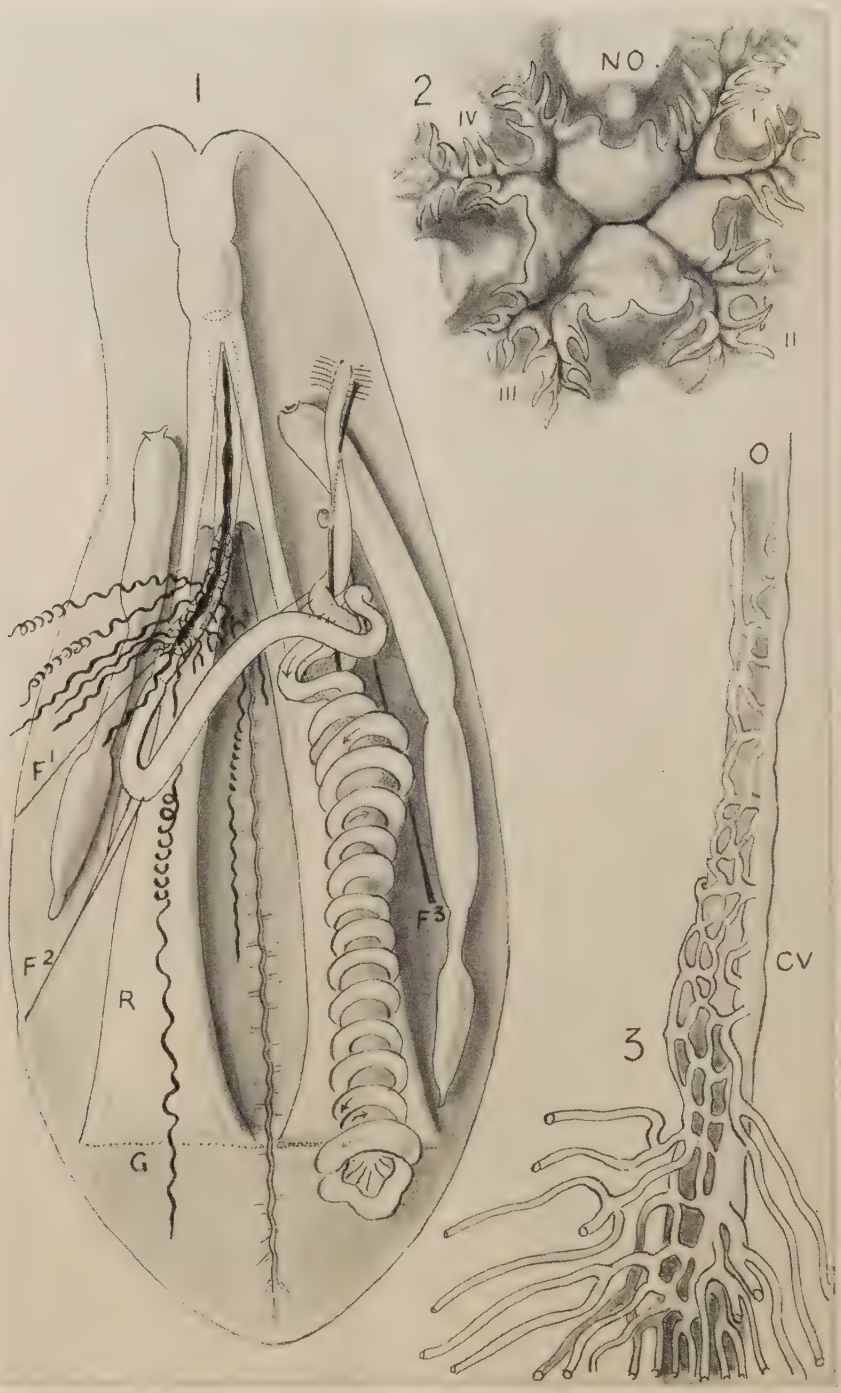


DENDROSTOMUM PYROIDES CHAMBERLIN AND D. PERIMECES FISHER.

SEE PAGE 445 FOR EXPLANATION.

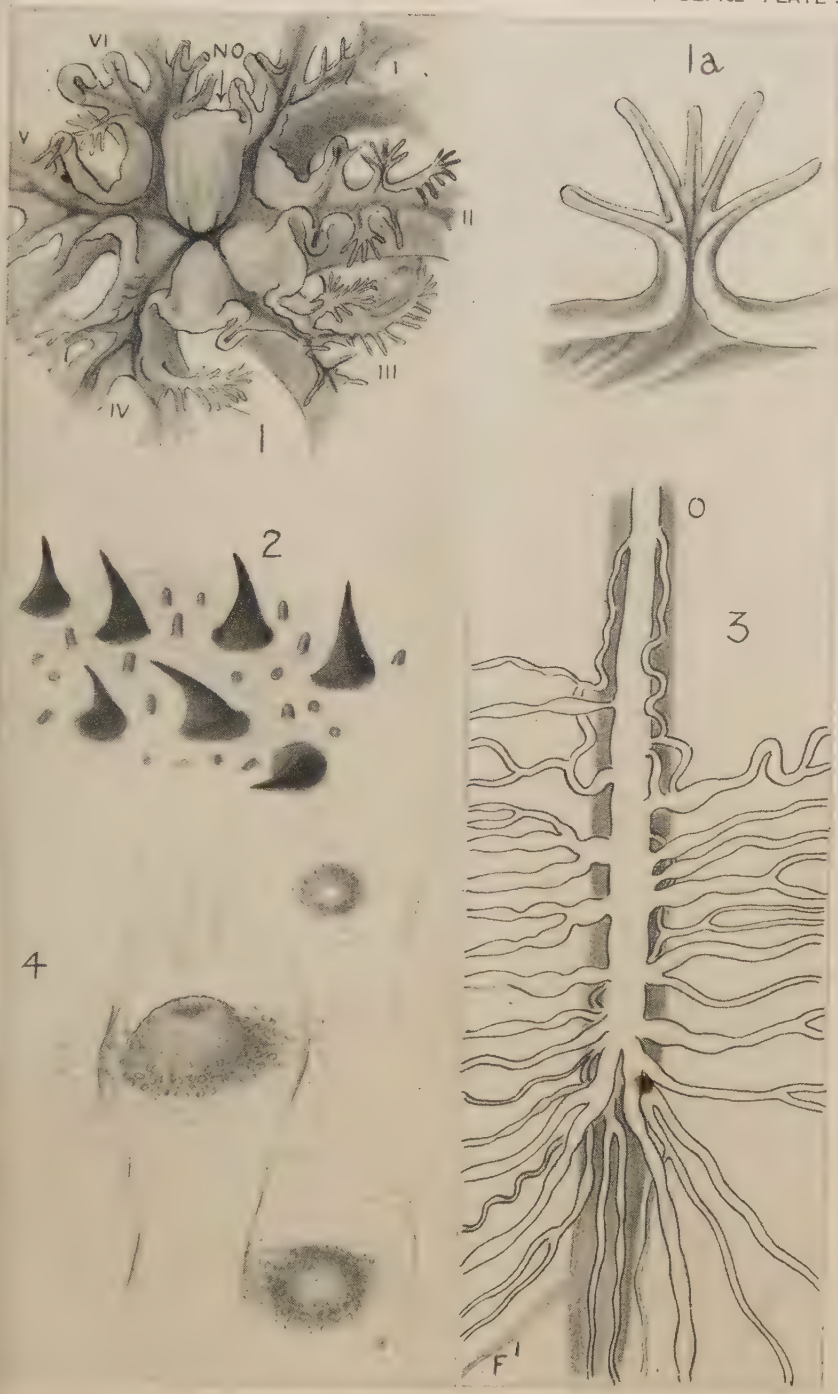
DENDROSTOMUM PERIMECES FISHER AND D. PYROIDES CHAMBERLIN.

SEE PAGE 446 FOR EXPLANATION.



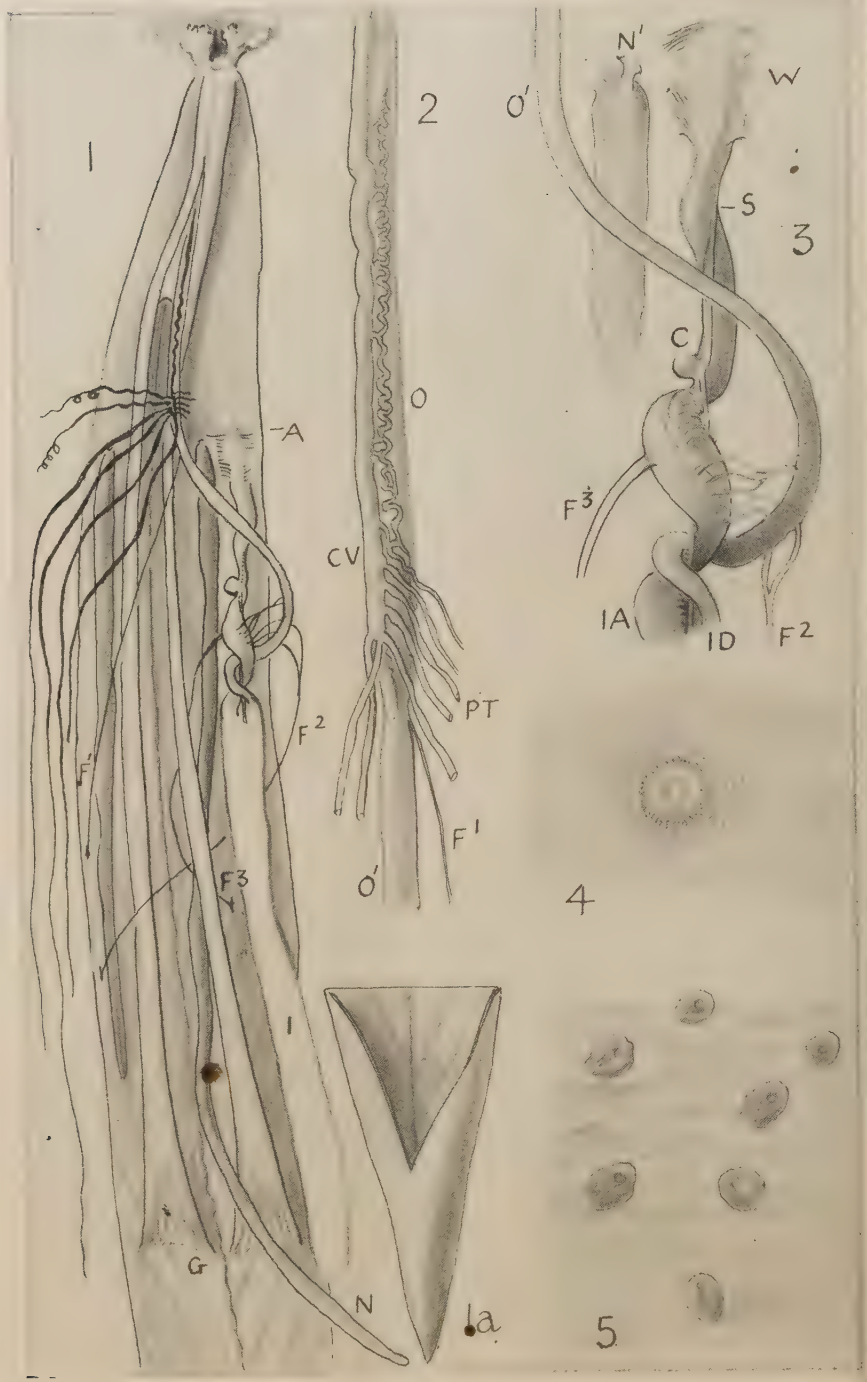
DENDROSTOMUM PYROIDES CHAMBERLIN.

SEE PAGE 446 FOR EXPLANATION.



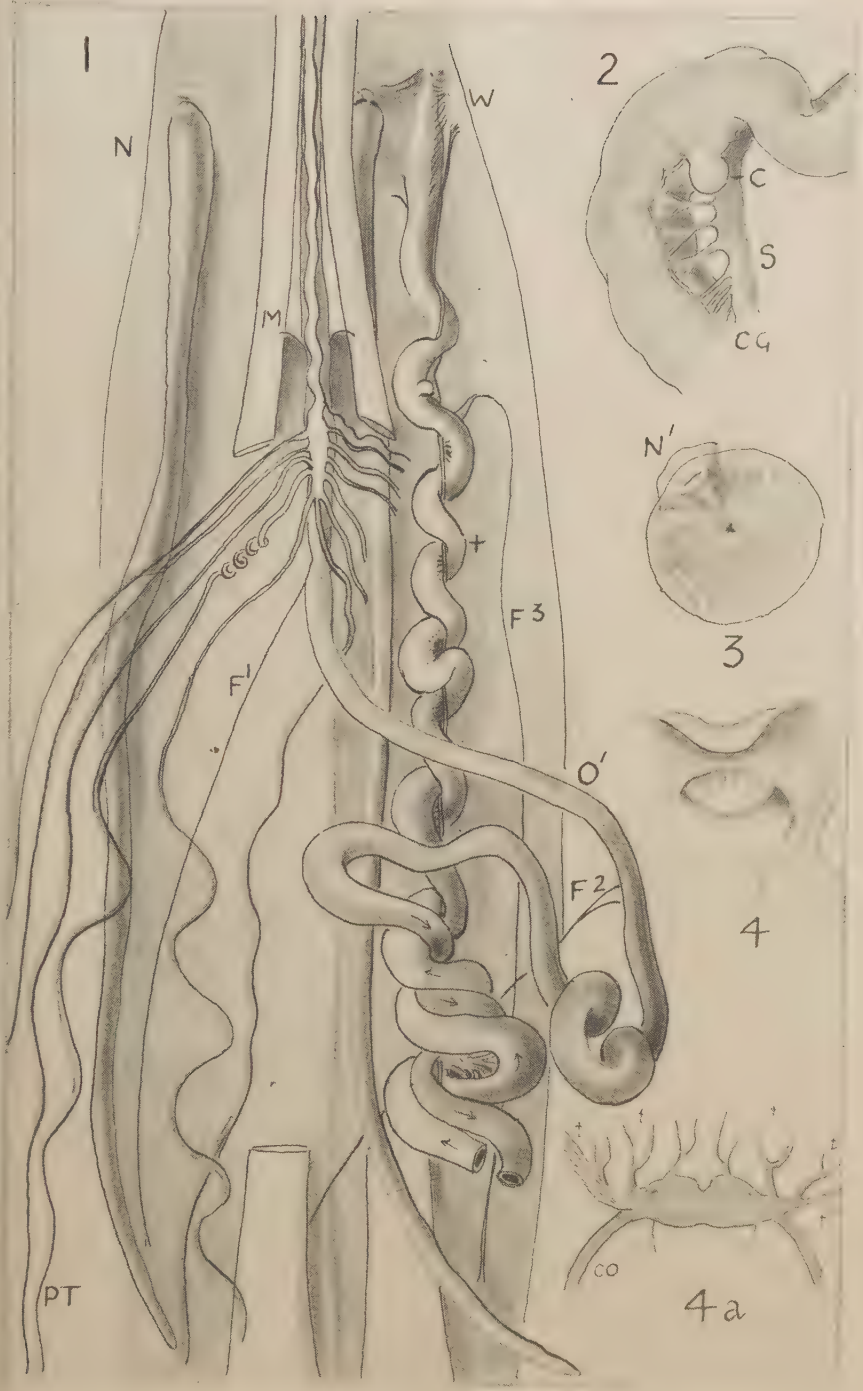
SPECIES OF DENDROSTOMUM.

SEE PAGE 447 FOR EXPLANATION.



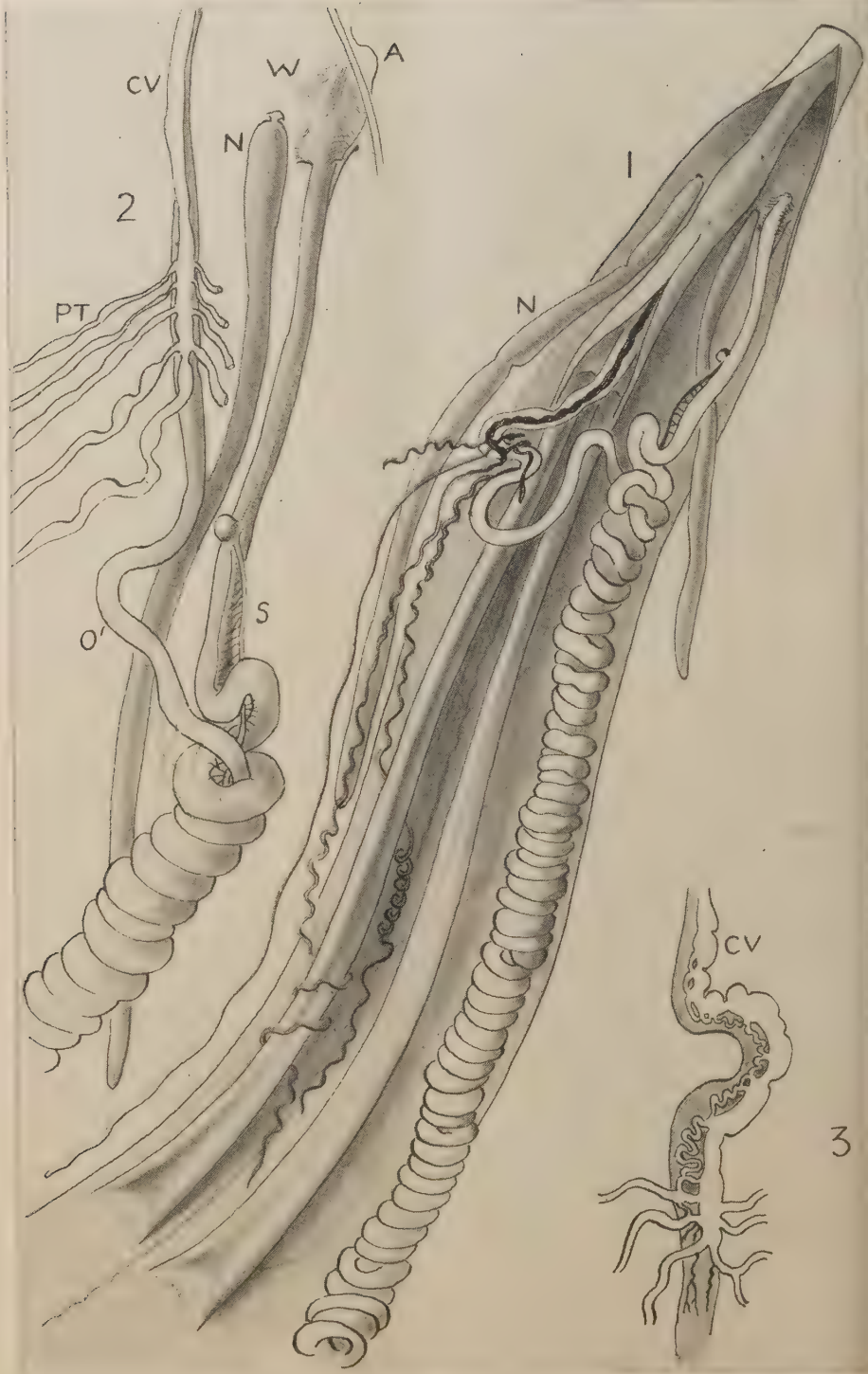
DENDROSTOMUM ZOSTERICOLUM CHAMBERLIN.

SEE PAGE 447 FOR EXPLANATION.



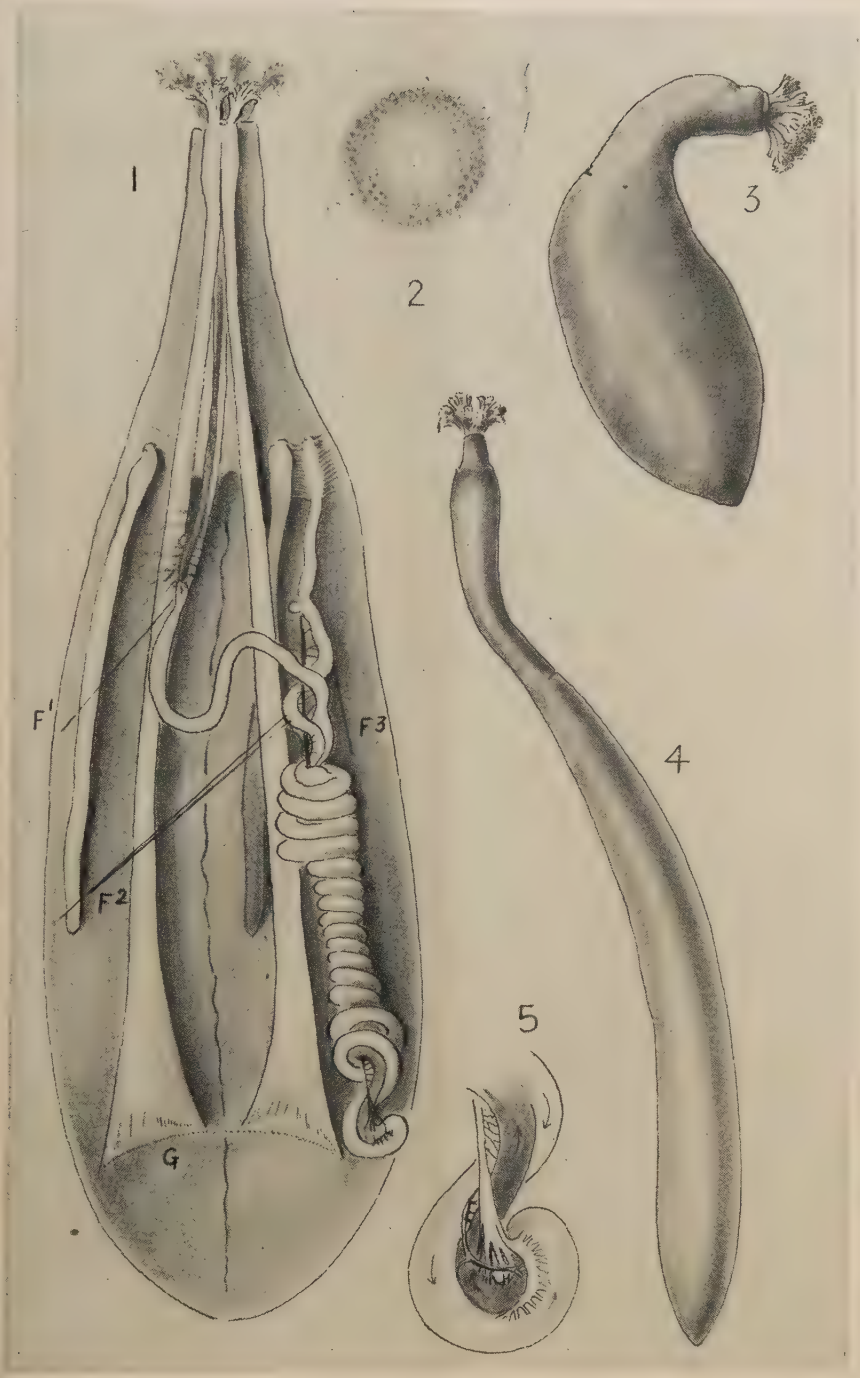
DENDROSTOMUM ZOSTERICOLUM CHAMBERLIN.

SEE PAGE 448 FOR EXPLANATION.



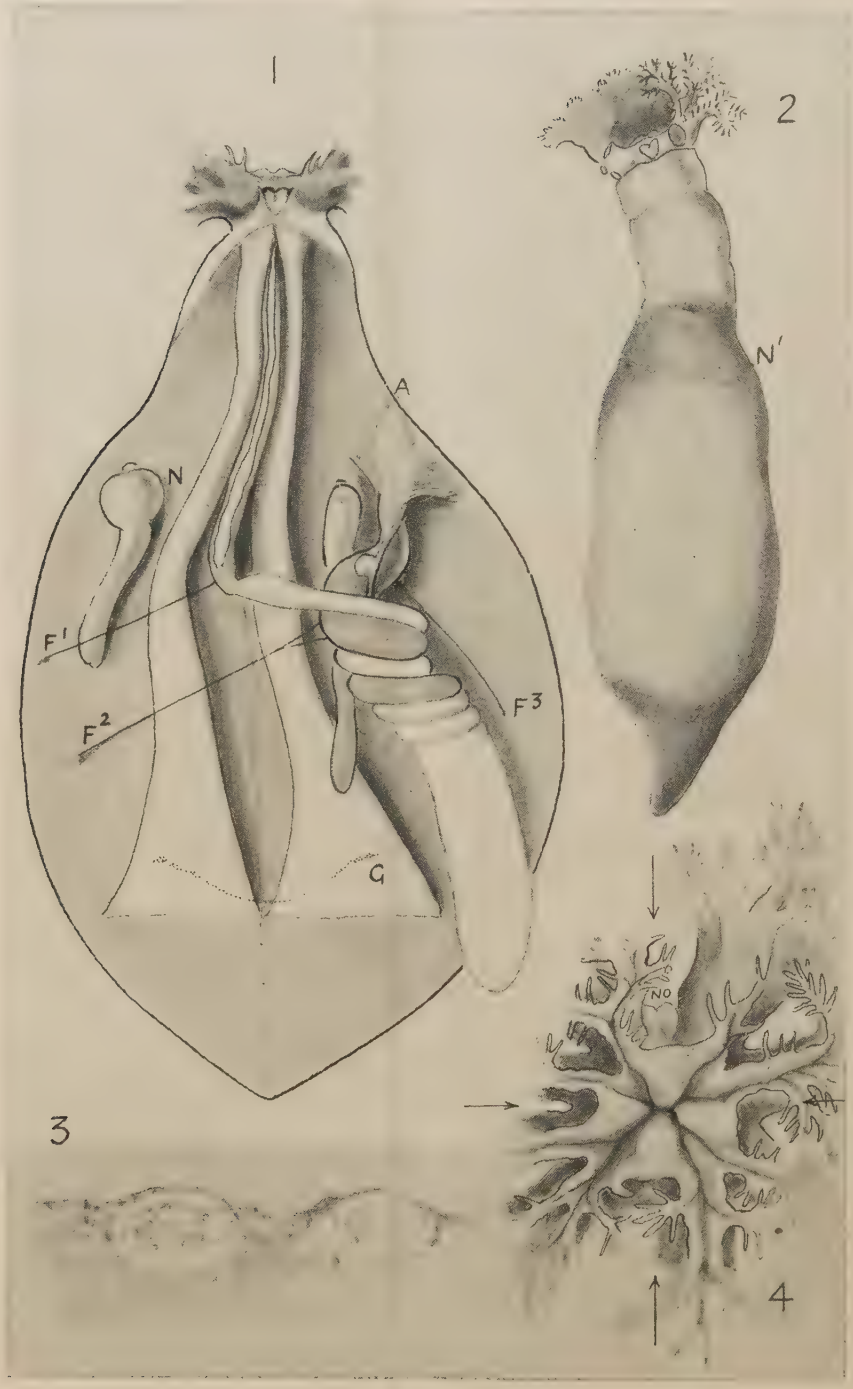
DENDROSTOMUM PERIMECES FISHER.

SEE PAGE 448 FOR EXPLANATION.



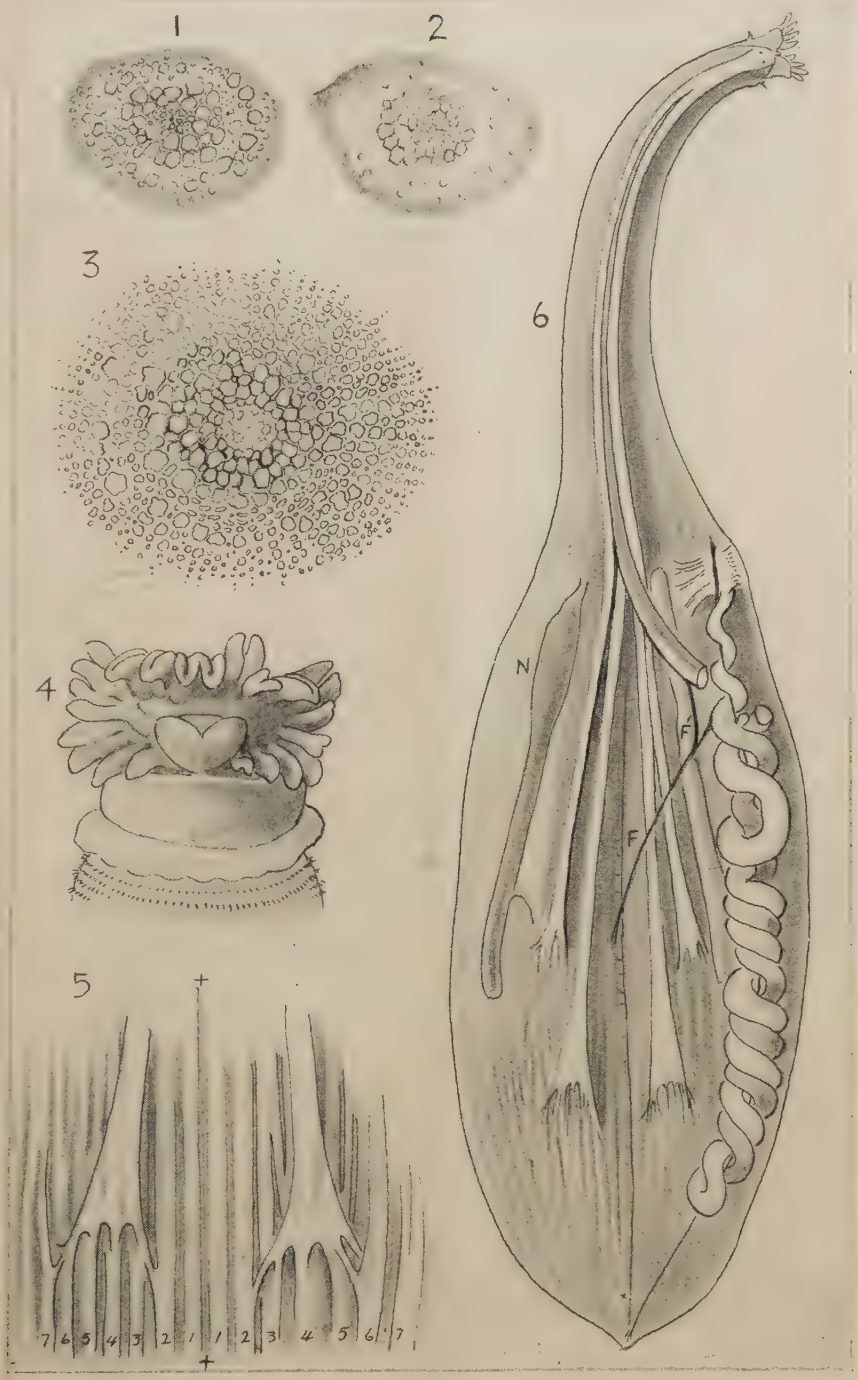
DENDROSTOMUM DYSCRITUM, NEW SPECIES.

SEE PAGE 448 FOR EXPLANATION.



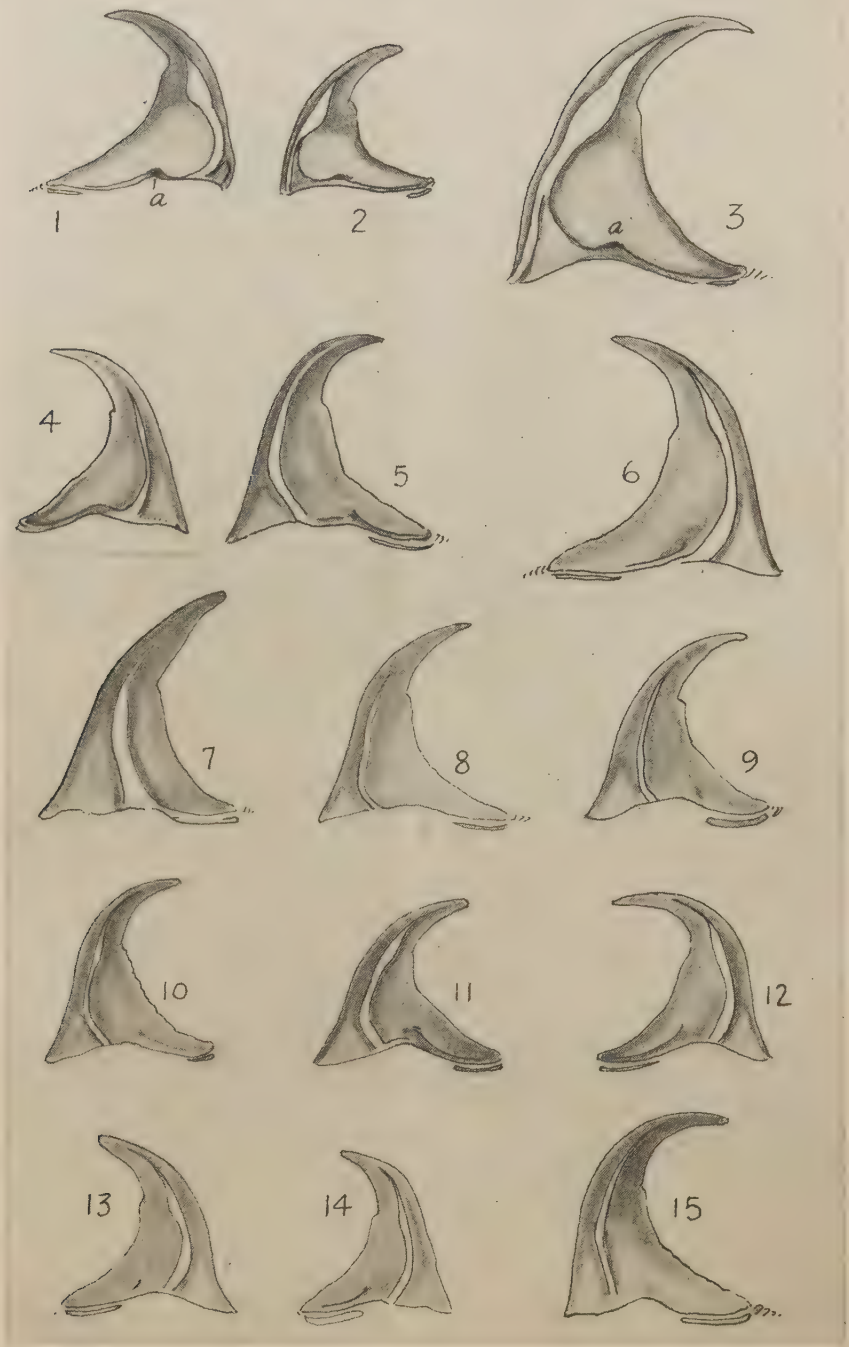
DENDROSTOMUM LISSUM, NEW SPECIES.

SEE PAGE 448 FOR EXPLANATION.



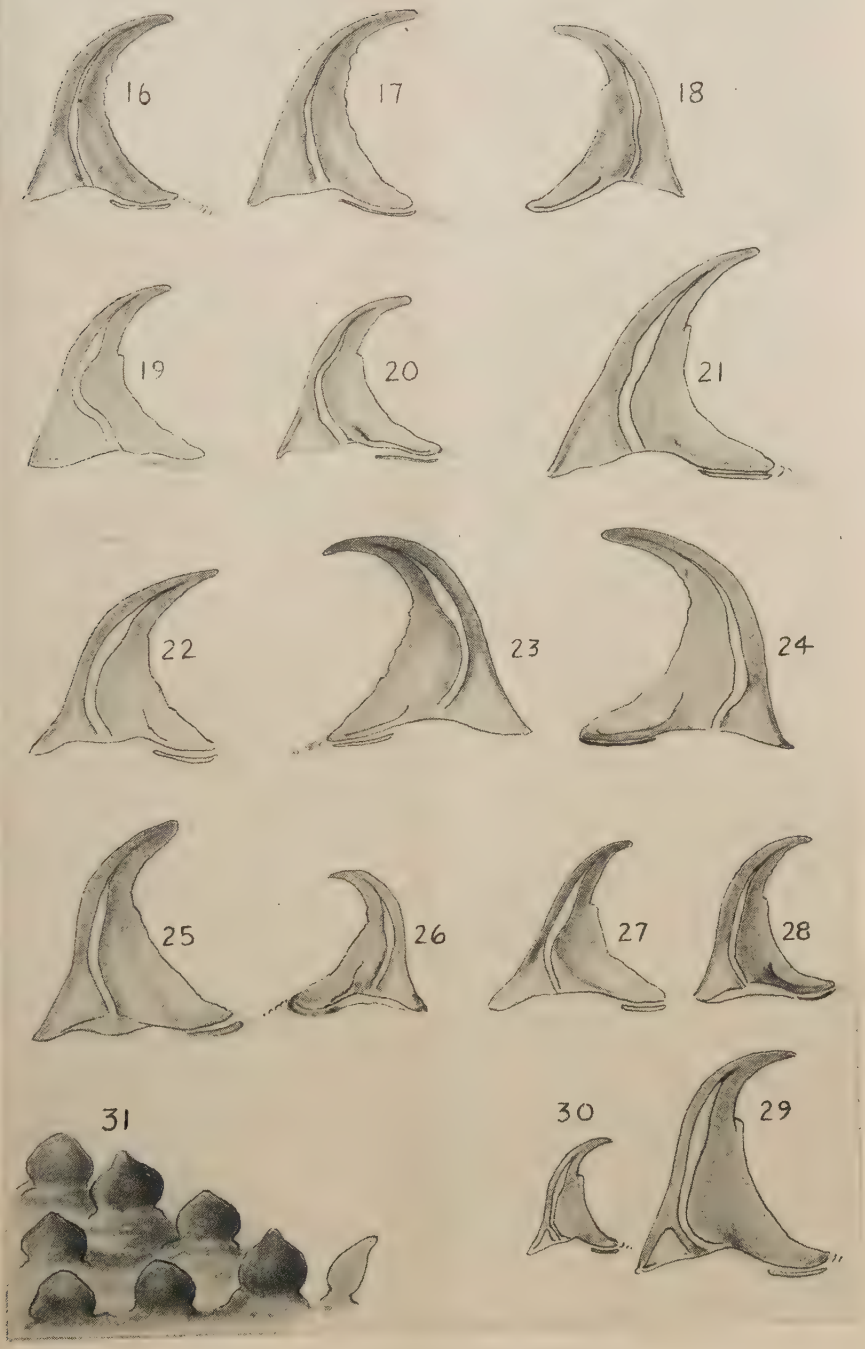
PHASCOLOSOMA PUNTARENAE GRUBE AND PH. AGASSIZII KEFERSTEIN.

SEE PAGE 449 FOR EXPLANATION.



PHASCOLOSOMA PUNTARENAE GRUBE AND PH. AGASSIZII KEFERSTEIN.

SEE PAGE 449 FOR EXPLANATION.



PHASCOLOSOMA AGASSIZII KEFERSTEIN.

SEE PAGE 450 FOR EXPLANATION.

SPECIES OF PHASCOLOSOMA.

SEE PAGE 450 FOR EXPLANATION.